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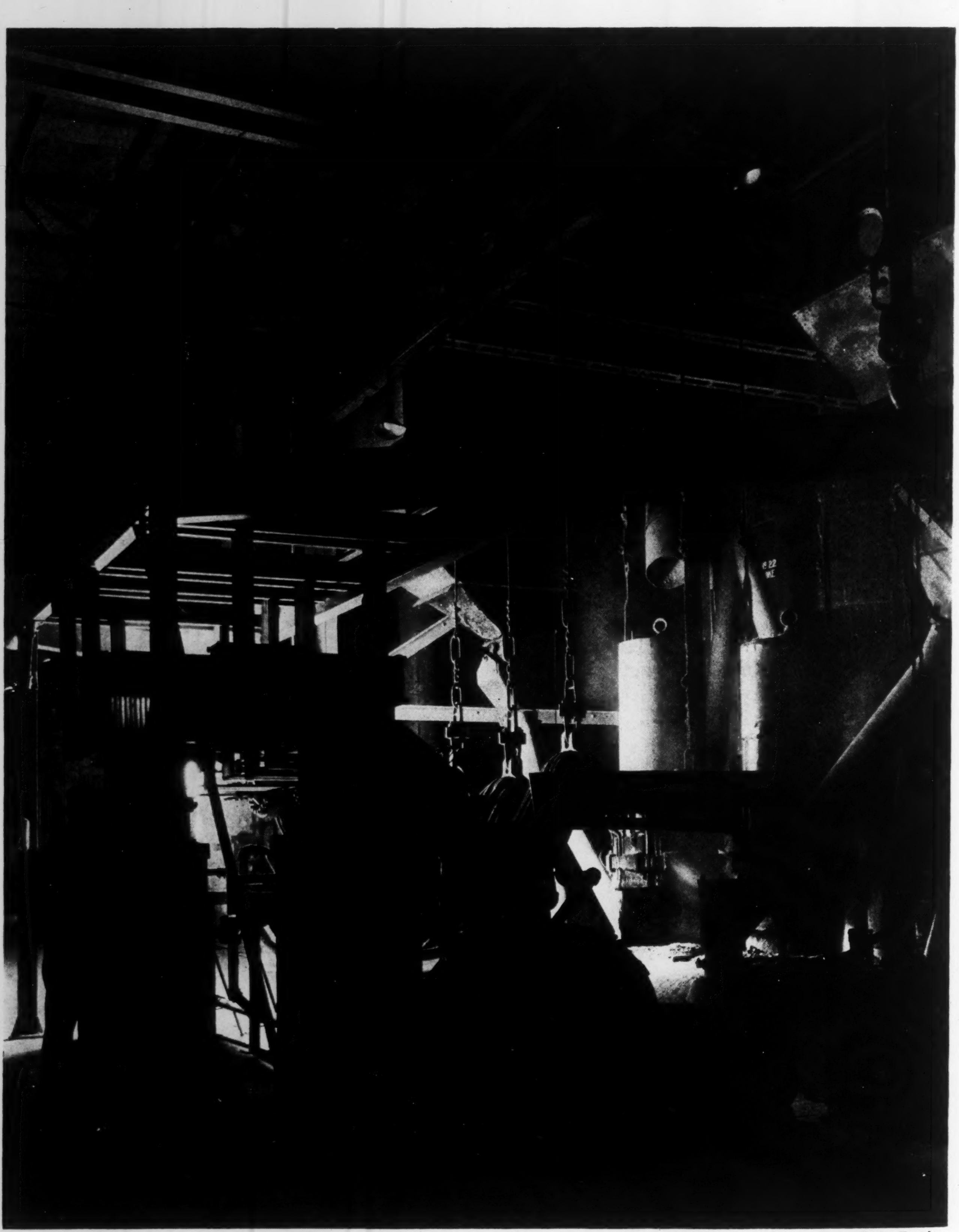

Charles Krutch

In a Southern Fertilizer Plant

(The fertilizer industry is one of those mentioned by R. M. Boarts, pp. 173–174, as changing the picture of Southern process industries)

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No. 3

MECHANICAL ENGINEERING

March
1937

GEORGE A. STETSON, *Editor*

Hard Work Ahead

BY COINCIDENCE appearing together in the same issue, this month's economic review, which bears the somewhat alarming title, "Massachusetts—a Declining State?" and two papers on industry in the South, provoke a long train of ideas not entirely inappropriate to Lincoln's birthday on which this is written.

Obviously, a community which sets up in a virtual wilderness a system of free public education at a time in the world's history when education is the privilege of a few, does more than sow the seeds of a future culture. For it also embarks upon a course which increases public expenditures, and it encourages its citizens to demand for their fellows constantly enlarging opportunities and consideration. But such has been the development of the pioneering spirit and social conscience of Massachusetts and of America in general.

Naturally, the forward surge of the industrial revolution and the building of the railroads brought with them the critical problems that always accompany changes in social and economic life. The metamorphosis of cottage industry into mill and factory was not easy for thoughtful citizens to comprehend. Opportunities for ruthless exploitation poisoned the social conscience and reaction to this poisoning expressed itself still further in efforts at regulation and control, for there were those not so blind that they could recognize slavery at home as easily as they could recognize it elsewhere. The beam in their own eye pained quite as much as the mote in their brother's eye. One result was the taxation and social legislation to which Professor Maclaurin calls attention in his review.

It is clear that the development of a social conscience has been bought by Massachusetts at a price which some consider dear. Many will argue that its industries have suffered. But if we turn from Professor Maclaurin's review to the papers on industry in the South we find emphasis placed on inevitable phases of industrial and social development that suggest a larger view. "Industry is never secure," writes Professor Wilkinson. "For a nation or an area to feel too secure in its supremacy over other nations and areas is not good, economically or socially." Where in the world today can we look and not see the working out of this universal principle?

Modern civilization, through science and the machine, has become a great leveler in respect to special advantages gained through native resources and abilities. Competition quickens and complicates living and security. If Massachusetts, if the South, if America itself wills to persist, the courage, faith, and intelligence of pioneers must be adapted to the world as it exists today and to the special hazards and advantages that face the community. On engineers, who are responsible for creating many of the changes and complications that exist today, rests an obligation to provide means for progress and survival. It is not their obligation alone; and their task is made difficult by those who are confused or who misuse the forces at work. But a survey of what has been accomplished should inspire the faith in what may be and in the fundamental philosophy that courage and unremitting hard work may win further benefits and avoid predicted disaster. It is too soon to assume that machinery is an evil, that we produce too much, that we can rest on our oars and enjoy without interruption the fruits of leisure. The world is not yet, and never may be, ready for the perpetual enjoyment of fruits won in the past. Hard work lies ahead.

Satisfaction of Society Service

SINCE the first of the year a number of reunion dinners and luncheons have been held at which members of committees of The American Society of Mechanical Engineers have met to express their appreciation of the services of their chairmen. No one privileged to look in at these gatherings can come away without holding a better opinion of Society administration.

The reunion gatherings referred to have a threefold purpose. First, they permit members of the committee in question and officers of the Society to honor a recently retired chairman who has given at least five years to committee work. Second, they bring together former members of the committee, thus preserving a continuing association of men who have had long and varied experiences with certain aspects of Society administration, and serve to introduce the newer members of the committees to the tasks that lie before them. Finally, they divert the attention of the committee from the specific details of immediate problems to long-range discussions of general policies in an atmosphere highly charged with wide experience and wise counsel.

It is at such gatherings as these that consciousness dawns of what its members as individuals mean to the Society and what the Society and the opportunity of serving it has meant to the men themselves.

Fortunately, although reference has been made to the administrative committees only, opportunities for experiencing the satisfactions of these services and associations are not confined to their members. A surprisingly large percentage of members of the Society will be found serving it on numerous committees and in its local sections. In greater or lesser degree, as members develop the possibilities of their associations and services, they come to an appreciation of the values they represent and develop bonds of sympathy and understanding without which no profession can be said to have cohesion of purpose or recognizable individuality. It is such associations that the young engineer can look forward to as providing him the richest promise.

A.S.M.E. Boiler Code Committee

OCCASION for commenting on the Boiler Code Committee of The American Society of Mechanical Engineers is provided by a recent birthday celebration staged by that committee for its beloved chairman, D. S. Jacobus.

Members of the Society whose acquaintance with the committee does not extend beyond amazement at the mixed typography of certain sections of this magazine devoted to interpretation of the code are too infrequently reminded of the history and achievements of this important service.

Primarily as a result of a demand for safety standards for steam boilers, the committee came into existence in 1911, when state inspection departments and safety laws, insurance companies, consulting engineers, users, and the manufacturers of boilers found it necessary to give individual consideration to practically every design and every boiler built, and to do so under conditions and requirements that differed in almost every location. Prior to this time in states where no safety laws were in force, an uninformed public was faced with a lack of assurance that boilers sold to them conformed to specifications that provided reasonable safety because no generally accepted standards had been set up. It is obviously unnecessary to enlarge upon the numerous implications of this state of affairs as they existed when The American Society of Mechanical Engineers undertook the work of codification in the boiler field.

By 1914 the first edition of the Boiler Code was issued and, thanks to the wisdom which prevailed in its drafting, it won almost immediately the hearty approval of those competent to judge its merits. Power and heating boilers were covered in this first draft which, with revisions in 1918, 1924, 1927, 1930, and 1933, has been expanded to include eight sections covering power boilers, material specifications, locomotive boilers, low-pressure heating boilers, miniature boilers, rules for inspection, unfired pressure vessels, and suggested rules for care of power boilers.

That the code has won its way in public approval to the extent of becoming national in scope is attested by the fact that it has been adopted by 21 states and 18 municipalities as local regulations. The committee's code symbol stamp, imprinted on boilers constructed under its code, is the "hallmark" by which conformance to the requirements of the code is shown.

It is obvious that back of the code is a body of men whose intelligence and integrity of purpose are guarantees of its worth and authority. It is easy to appear to be overstating the facts in speaking of the qualities and achievements of this group of men. Drawn from every field concerned with the common problem, these men meet monthly to interpret individual cases arising under the various codes and to consider what revisions and additions are indicated by changes in engineering practice. The codes are in this manner endowed with a vitality that insures not only the best interests of all concerned but also that adaptability without which they might become brakes on progress. In spite of the special personal interests that members of the committee must naturally have, it is the practical idealism implicit in the codes that provides the common ground upon which decisions, which must have unanimous approval, are made. That this makes for spirited debate goes without saying, but it also results in decisions that are received with deserved confidence in their justness and validity.

There is a significance in the success of the Boiler Code Committee that calls for comment and provokes the wish that more groups might be organized to perform similar services in our national life. Here, in a very narrow and highly technical field, is to be found an example of the spirit of the finest cooperation under democratic institutions. Fundamentally, and in spite of its acceptance by governmental agencies, the boiler code is an example of what competent and interested groups can do for their own and the public's welfare. No central governmental agency dictates to it. No powerful special interests warp its efforts to their own ends. In its special field it represents the flowering of the democratic spirit—a regulation by rule rather than an individual.

One other thought will bring all engineers into the sphere of influence exercised by the Boiler Code Committee. The competence and special knowledge of the persons who comprise the committee give authority to its judgments. But public confidence in the integrity of these judgments and the atmosphere in which they are formed are derived from the fact that the committee is a representative of The American Society of Mechanical Engineers. It partakes of, as it contributes to, the prestige of that larger body—a prestige made and shared by all who comprise its membership.

A.S.M.E. Membership List Mailed

The 1937 A.S.M.E. Membership List has been mailed to all members of the Society as the second section of the Transactions for February and hence will be found in the mailing envelop marked Transactions. The 1937 Membership List also includes names of officers and lists of Society Committees for 1937.

MAGNAFLUX INSPECTION *of* PRESSURE-VESSEL WELDS

BY J. W. YANT

STANDARD OIL COMPANY OF INDIANA, WHITING, IND.

APPLICATION of the magnaflux test to pressure-vessel welds is a rather recent development, oil companies having specified it on certain classes of this work only within the last 18 months. This method of testing was first applied by our company to the alloy welds of vessels lined with ferritic stainless steel in which the liner was fastened to the carbon-steel backing plate by resistance or arc welding, or a combination of both. Subsequently, magnafluxing was used as a final test after the hydrostatic test for all welds of vessels not X-rayed and for all welds of vessels X-rayed before stress relieving. Where vessels have been X-rayed after stress relieving, the test has been applied only to welds, such as nozzle, manhole, and supporting-lug welds, that could not be X-rayed.

COMPLETE OR LOCAL MAGNETIZATION MUST PRECEDE TESTING

A pressure vessel to be magnaflux tested must first be magnetized. Therefore, this test is not applicable to welds of the nonmagnetic austenitic-type steels such as the 18 per cent Cr, 8 per cent Ni grade. Vessels may be either completely or locally magnetized, depending somewhat on preference or on the quantity of testing to be done. Where vessels are large and have many feet of welded seam to be tested, or where a vessel is alloy lined for corrosion resistance and the entire inner surface is to be tested, magnetizing the whole vessel at once is probably most convenient for the inspector. Where only a small length of welded joint is to be tested, local magnetization by either of two methods may be quicker. However, some manufacturers prefer to use local magnetization even though large areas are to be tested. Where large areas are tested by either complete or local magnetization, they should be mapped so that no portion will escape inspection.

A vessel to be magnetized entirely is wrapped with cable, and to perform a thorough job of testing it must be tested separately with a girth wrapping and with a longitudinal wrapping. Welder's cable is satisfactory. The first step is winding from 6 to 14 turns of cable around the girth of a vessel at the center and connecting the cable ends to the terminals of a welding generator. The quantity of current to be used can be gaged roughly by determining whether the ends of the vessel are magnetized enough to attract small pieces of steel. On a vessel of $1^{9}/_{16}$ in. wall thickness, 8 ft diameter, and 40 ft long, wrapped with eight turns of cable, a current of 300 amp has produced satisfactory magnetization.

When the vessel is magnetized, the test is performed by sprinkling magnaflux powder, which is finely divided iron, mixed with some other ingredients, lightly over the weld and striking the plate alongside the weld with a hammer to cause the powder to arrange itself and line up over any defects that are present. Where a crack exists in a magnetized vessel, the powder will attempt to bridge the gap between the two edges. Should the vessel be rather strongly magnetized, the powder may line up on the high spots of the ripples of a cover bead or at sharp changes of contour but a light jet of air will remove such lines. If a crack is present, even a strong jet of air will not remove the powder line.

If the surface of a weld to be tested slopes too much, the magnaflux powder will slide off and will not give a good indication. When testing circumferential seams, the vessel must be rolled as the testing progresses and only that portion of the seam, from which powder will not slide off too readily, tested.

When a vessel is magnetized by energized cables wrapped around the circumference, the path of the magnetic flux is parallel with the longitudinal axis, and weld defects, such as cracks perpendicular to the flux path, will cause the greatest magnetic disturbance and will show powder lines more readily than defects parallel with the flux path. Weld cracks running parallel with the flux path, that is, perpendicular to the cables, may not show at all. Thus, to insure that dangerous weld imperfections are not missed, cable must be wrapped around the vessel a second time—this time in a longitudinal direction.

In longitudinal cable winding, nozzles in each head are an advantage since the cable is then led in the nozzle at one end, out the nozzle at the other end, and carried back along the outside of the shell and again inserted through the entrance nozzle until six or eight turns are made. The cable ends are attached to the terminals of a welding generator. Wrapping cables longitudinally is a more efficient way of magnetizing, since the magnetic flux has a complete metallic path around the circumference as compared with the air path from end to end of a girth-wrapped vessel.

If a vessel does not have a nozzle in the upper head, the cable can be brought out through a side nozzle or manhole near the top. The vessel will not be magnetized beyond the cables and a portable means of magnetization such as electromagnets must be used to test the remainder. If an upper-head nozzle is too small to accommodate enough turns of cable, a set of bus bars can sometimes be made up, each one being insulated from the other, and the assembly inserted through the nozzle. The individual turns of the cable can each be attached both inside and out to a separate bus bar, and the circuit completed in that manner.

PORTABLE ELECTROMAGNETS PROVIDE LOCAL MAGNETIZATION

When a vessel is small or when the quantity of welding to be tested does not justify magnetizing the whole assembly, a pair of portable electromagnets or one with a U-shaped core can be used to magnetize small areas at a time. About a foot of seam should be tested at a time, once with the magnets straddling the seam and once with the magnets about 1 ft apart on the seam. This procedure should locate either longitudinal or transverse cracks in a weld. The electromagnets

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Presented at the Welding Practice Symposium which was sponsored jointly by THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS and American Welding Society, Oct. 22–23, 1936, Cleveland, Ohio.

will be found rather burdensome to handle due to their weight if much welding is to be tested.

Another means of local magnetization is to pass a heavy current through the area to be tested. This can be accomplished by an apparatus having two metal fingers set in an insulating handle, and having no contact with each other. The contact points are pressed on the surface of the vessel, the area between them is magnetized by the flow of current and the test is made while the current is on.

The defect most readily indicated by the magnaflux test is a crack that extends to the surface of the weld, even the shallowest crack or checks showing a powder line. In numerous welds of an air-hardening steel, the radiographs of a given length of welded seam showed no defects, but a powder line appeared on the magnaflux test. The cause of the powder line was determined by chipping and, in each instance, was found to be a surface crack about $^1/_{64}$ in. deep. Since the total thickness of the weld was about $1^3/_4$ in., the cracks were too shallow to show on the radiographs and, without the aid of the magnaflux test, were invisible although some could be seen with a magnifying glass.

More serious defects have been found in welds around nozzles and manholes. In one case, the outside fillet weld around a 20-in. manhole of the integral reinforcing-pad, extended-neck type was being tested. Before the magnaflux test, an air pressure of 100 lb had been introduced between the vessel plate and the nozzle pad, and painting the weld with a soap solution revealed no leaks. In magnafluxing, the powder tended to concentrate in the crevasses that were located between the circumferential beads of weld used to build up the outside fillet around the manhole pad, but it could be blown away easily, indicating that a sharp change in section, and not a crack, was causing the powder lines. At one location in the fillet, a powder line 1 in. long that crossed one bead of weld could not be removed with an air jet. Exploration of the cause of this powder line showed that the outside fillet weld was cracked for three quarters of the distance around the manhole although the crack had come to the surface only at the location of the powder line.

Weld cracks extending perpendicular to the wrapping cables may not be found by magnaflux testing. In a vessel that had not been X-rayed, the cables were first wrapped circumferentially, and several transverse cracks were found in two girth seams. When the same seams were later tested with the cables wrapped longitudinally, many more transverse cracks were found.

An unexpected location of cracks in a pressure vessel was found while the head seams of a drum with a wall $^9/_{16}$ in. thick were being tested. The powder falling on the tangential section of the head formed a multitude of lines parallel to the axis of the vessel around nearly two thirds the circumference of each head. When the powder was blown away, very fine lines could be seen on the surface of the oxide scale. The scale was ground away and the metal itself was found to be checked. About $^1/_{16}$ in. of metal had to be removed to eliminate these checks or cracks which had probably been produced in the head-forming operation. Had the magnaflux powder not fallen on these heads more or less by chance, this vessel would have left the shop containing many cracks which were probably of little consequence at the time but might have developed into something more dangerous in service.

MAGNAFLUX TEST USUALLY DOES NOT SHOW SUBSURFACE DEFECTS

While some users of this test have reported finding subsurface defects repeatedly in other classes of work, its efficacy for detecting subsurface defects in pressure-vessel welds is open to question. With the exception of subsurface porosity which will be discussed later, the writer has never found any subsurface defects by this test, either during routine inspections or laboratory investigations. Most of the welds covered by the routine inspections had been X-rayed and repaired before the magnaflux test and, therefore, were not expected to reveal any defects of importance other than cracks that might have developed subsequent to the X-raying. Other pressure-vessel welds were not X-rayed at any time, however, and, in all probability, contained some subsurface defects when magnafluxed. The specimens investigated in the laboratory were welds that were known to contain slag inclusions and unfused lip edges which, however, could not be located by magnafluxing.

Better testing conditions would prevail if the cover beads on welded seams were removed and nozzle and manhole fillets were chipped smooth. If this procedure did nothing else, it would remove the cause of false indications such as powder lining-up in grooves between beads on nozzle fillets or powder lines forming on the ripples and ridges of a seam cover bead. Furthermore, detection of subsurface defects might be made more certain.

Strangely enough, one clear-cut detection of subsurface defects was the location of porosity, a type of weld imperfection which, due to the relatively small size of the individual centers of magnetic disturbance, would seem to offer the least opportunity for location by magnaflux. In this case, the welds of nine 20-in., integral reinforcing-pad, extended-neck manholes, each located in an elliptical head, were magnafluxed before the heads were attached to the cylindrical sections of the vessels. The inside weld between the vessel and the extended neck had been built up two heads higher than the inside surface of the head and had been chipped and ground flush. No porosity was visible on the surface. In testing these welds, the powder clung to the surface in many small spots on three of the manhole welds after the bulk of the powder had been blown away with a mild air jet. A number of these individual locations were marked, the magnaflux test repeated, and the powder adhered to the same spots. Chipping these welds opened up areas of considerable porosity extending to within $^1/_{16}$ in. of the surface.

In conclusion, while many defects have been located by magnafluxing, these with the exception of the three cases previously mentioned, have all been cracks that extended to the weld surface. On several occasions known defects in welds were not found by magnaflux testing, although it is exceedingly well-adapted to some weld investigations. In testing the welding contained in a magnetic stainless-steel vessel-liner, no other type of test will indicate the cracks as completely. However, a valuable supplement to the magnaflux test on lined vessels is a hydrostatic test using a light oil. If a liner is not bottle tight, oil will collect between the liner and the carbon-steel plate. When the vessel is opened and drained, the oil will seep out of any cracks in the liner for as long as a week. Although the oil test will not disclose all the cracks in a liner, it may disclose some defects that were overlooked in the magnaflux test.

As a final test of vessel welds, such as those around nozzles and manholes, whose position makes them impossible to X-ray; as a final test of longitudinal and girth seams subsequent to radiographing and stress relieving; or as a final test of class-2 vessels, magnafluxing is of definite use in determining whether these welds are cracked. Thus, this test as applied to pressure-vessel welds is a useful auxiliary to the X-ray test and, should a technique be developed which would locate subsurface defects more readily and definitely, could become of even greater utility.

DETECTION *of* FATIGUE CRACKS *by* MAGNAFLUX METHOD

By T. C. RATHBONE

ENGINEERING DEPARTMEMT, FIDELITY & CASUALTY CO. OF NEW YORK

DETECTION OF cracks and flaws in boiler drums and other pressure vessels by a process of magnetizing the object and applying a magnetic powder is being described in other papers that are printed elsewhere in this issue. The application of this method of inspection to ferrous objects in general, and in particular to the types of crack that develop in machinery parts as a result of dynamic forces may be of general interest.

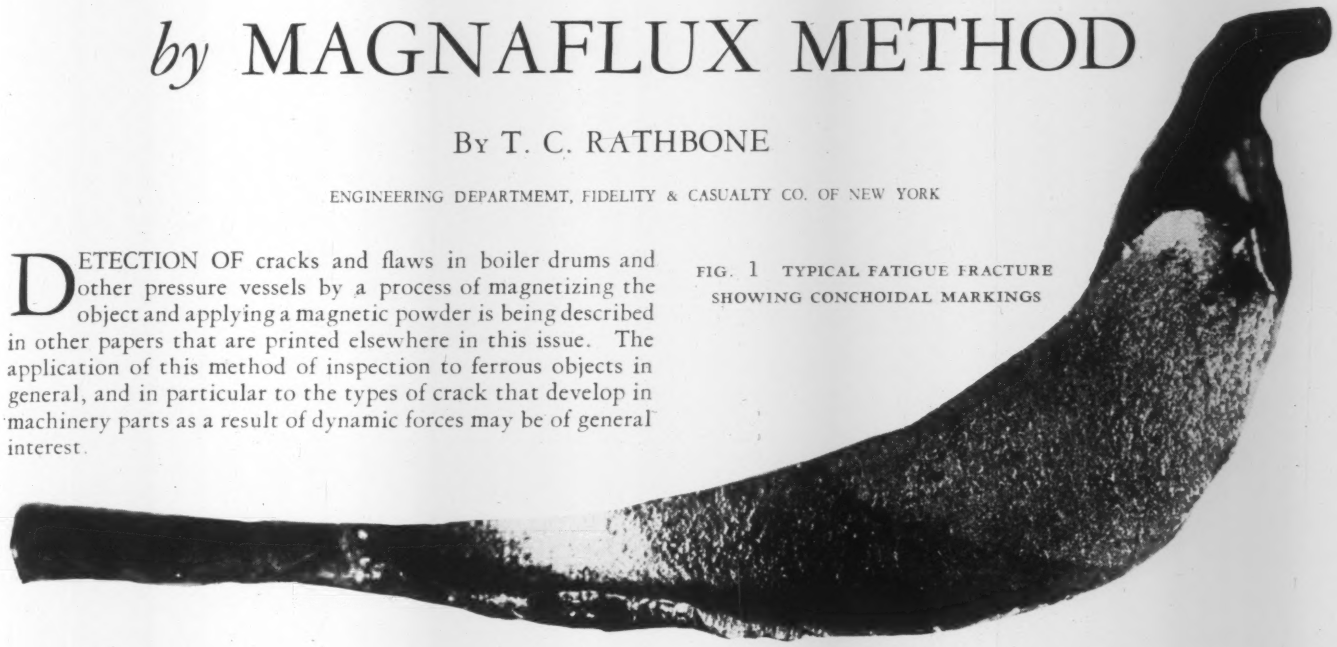


FIG. 1 TYPICAL FATIGUE FRACTURE SHOWING CONCHOIDAL MARKINGS

The chief characteristics of the true fatigue crack are its unexpected start and relatively slow progress, giving rise to the synonymous term "progressive fracture," and its invisibility, particularly in the early stages, which so often prevents detection. The degree of invisibility of fatigue cracks is often astonishing. Unless actual examples have been seen, it is difficult to believe that a well-developed crack can exist in a machine part under direct scrutiny without being visible, even with the aid of a magnifying glass.

Materials may fail at stresses considerably below the ultimate in direct tension, if the forces are applied in an intermittent or repeated reversal fashion. For a given material, a fairly definite relationship has been established between maximum fiber stress and the number of cycles of stress reversals required to start failure. From such data, the so-called endurance limit has been introduced in machine design, which is supposed to be the maximum allowable stress that can be applied with an infinite number of reversals without starting fracture. All machinery parts subjected to reciprocating forces from any cause are now designed in conformity with this principle. In spite of this, failures due to fatigue or progressive fracture are still being experienced to an alarming degree.

CAUSES OF EXCESSIVE STRESSES

These failures are fundamentally due to the existence of stresses beyond the endurance limit, in spite of the provisions in design to avoid this very condition. These excessive and unanticipated stresses leading to failure are almost always due to one or a combination of the three following causes (*a*) a metallurgical flaw, (*b*) stress concentration, and (*c*) stress from excessive vibratory movement.

By metallurgical flaw is meant defective metal, such as slag inclusion, folds, injury to structure from improper heat-treatment, residual stresses, and the like. That failures in this category are becoming more and more rare is a tribute to the metallurgists.

Excessive stress-concentration may be due to faulty design or to accident. The magnification of stress at points of discontinuity or sudden changes in section is now fairly well understood and taken into account in modern design. The advance in the photoelastic art, wherein machine-part models of suitable material are examined under stress with polarized light, has added greatly to our knowledge of the magnitude of stress concentrations or stress raisers at discontinuous points, such as at sharp changes of section, holes, notches, and the like. The stresses in complicated, three-dimensional parts are not so easily determinable, and, therefore, may become greater than intended.

Accidental stress concentrations due to nicks or other damage are far more potent than is generally realized and have been the direct cause of many fatigue cracks. A sharp nick or a fine grinding or quenching crack at the right point may magnify the local stress to a value that is many times higher than the calculated stress at that point and start progressive fracture. For this reason, the search for cracks should be intensified in the neighborhood of nicks and other surface damage. If the normal working stresses are high, nicks that are almost microscopic become important. As an example, merely stoning the edges of steam-turbine blades raised their endurance to stress reversals in a fatigue-testing machine from five to ten times. Artificial nicks, such as can be made with a razor blade, can start a fracture at a considerable distance away from the theoretical location of the maximum fiber stress.

The root of a thread makes an admirable nick for unintentionally producing high stress concentrations. Thread roots are especially vicious because they are usually located at nodes or points where the normal stresses are high, for example, where pipes are screwed into heavy fittings.

In the foregoing, the dynamic forces and movements were

Presented at a joint meeting of the New York Section of the American Welding Society and the Metropolitan Section of The American Society of Mechanical Engineers, Jan. 13, 1937, New York, N. Y.

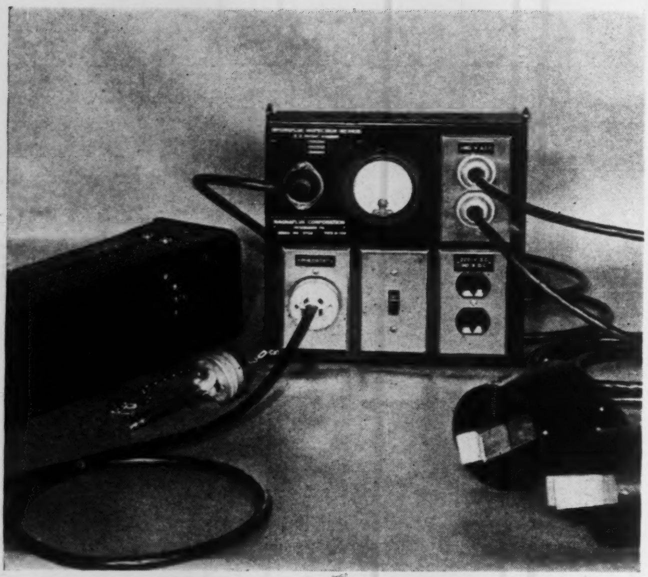


FIG. 2 PORTABLE MAGNETIZING SET

assumed to be under control and excessive stresses caused by local flaws or stress raisers. We come now to the third and probably most dangerous condition leading to excessive stresses, that due to vibratory movement beyond the anticipated range. No local flaw or nick is necessary to start fatigue cracks in this situation; the vibratory forces are sufficient to set up fiber stresses exceeding the endurance limit in perfectly sound material. When nicks or flaws do occur in combination, the situation is doubly aggravated, and the vibratory stress required to start fracture is reduced.

The problem of machinery vibration is a huge subject in itself and can only be discussed briefly here. Some knowledge of the manner in which machine parts can vibrate and set up stresses causing fracture is, however, a prerequisite for the intelligent search for cracks.

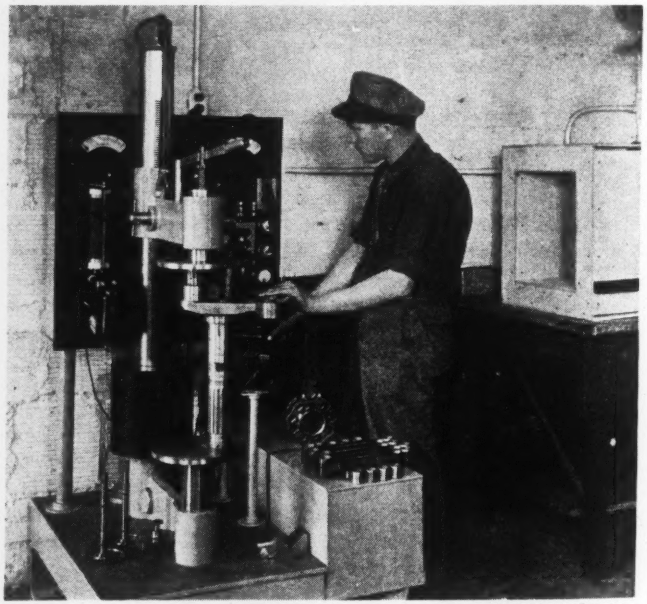
VIBRATORY MOVEMENTS CLASSIFIED

Vibratory movement is of several distinct types which fall naturally in the following classes: (*a*) forced vibration, (*b*) resonant vibration, (*c*) self-induced vibration, and (*d*) alternating movements due to temperature changes or other causes. Vibration is also classified as either linear, which usually can be observed directly, or torsional, in which no bodily displacement occurs and which usually requires stroboscopic means or other special apparatus to detect.

Forced vibration includes the deliberate and controlled straining movements that are inherent in reciprocating machinery parts such as piston rods, cranks, shafting, pedestals, and similar members, and in the shafting of purely rotative machinery, due to static loading and to centrifugal forces. In general, the magnitude of the stresses due to these types of forced vibration is more apt to be under the control of the designer and, hence, not so prone to become excessive and cause failure. An important exception, however, occurs in the case of crankshafts with bearing misalignment. The degree of misalignment is an accident, and the extent of the resulting stress reversals in the web once each revolution is more or less indeterminate. Likewise, the rotating bending stresses set up in the shafting of power machinery due to coupling misalignment or shaft distortion are a function of the degree of misalignment and, therefore, unpredictable. The crack in the web usually starts at the junction with the inner end of the crankpin. The shaft crack generally occurs at a change in diameter and is markedly influenced by the sharpness of the fillet.

All machinery, both in the complete unit and in its parts, has natural vibration frequencies that are inherent and unavoidable. These frequencies can be changed almost at will but cannot be eliminated. When the periodic reciprocating forces, due to the operation of the machine, synchronize with the natural frequency of the machine or any of its parts, the phenomenon of resonance, which is one of the greatest curses the engineer is called on to face, is encountered. Theoretically, the magnitude of vibratory movement that resonance can develop is unlimited; actually the amplitudes increase until something happens.

The dynamics of resonant vibration are thoroughly understood, but the practical calculations to predict or to avoid or to control it are a far different matter. The mathematical processes become extremely complex and involved. However, great headway has been made. The former mysterious cracking through of Diesel-engine shafting, which was so long a puzzle, is now rarely encountered. When torsional resonance was recognized as the cause, a calculation technique and special



United Air Lines

FIG. 3 MAGNETIZING OUTFIT USING HEAVY CURRENT

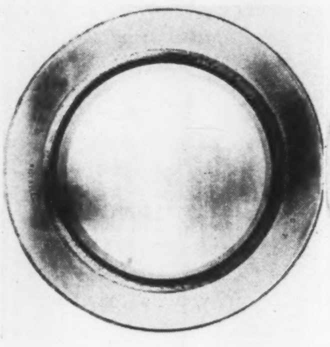


FIG. 4 RING BEFORE POWDER WAS APPLIED

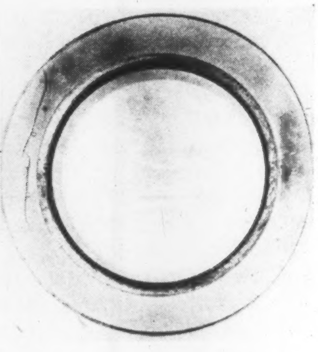


FIG. 5 CRACKS IN RING SHOWN BY POWDER

vibration apparatus, such as the Geiger torsiograph, were developed to detect and to avoid the critical condition.

The explosion of steam-turbine disk wheels is one of the most outstanding examples of the results of resonant vibration. These occurrences were very baffling until an unusual type of resonance was demonstrated to be the cause. Now, through brilliant dynamic analysis in design and careful periodic inspections, the difficulties are practically eliminated. Many cases of resonance in machine parts are still with us, some of which are extremely difficult to predict and avoid. Examples are steam and oil piping on turbines, turbine blading, foundations, and critical-speed vibration of rotating parts.

Sometimes an object can be made to vibrate violently at its own natural frequency, without the necessity for supplying periodic forces at that frequency. This is called self-induced vibration. The simplest example is the violin string, which vibrates at its natural frequency without any regard for natural frequencies in the bow. Organ pipes furnish another example. All that is necessary is a steady force input. If the natural frequency is changed by lengthening, tightening, or otherwise altering, the system simply vibrates at the new frequency. The singing or squealing water tap is a third example.

Many failures of turbine blading are believed to have been caused by fatigue from such self-excited vibration when the blades flutter in the steam flow. Other examples are the failure by fatigue of thin nozzle vanes and some failures in valve parts and condenser tubes. The fact, that in many such failures the natural frequencies of the parts bore no relation whatever to the speed of rotation or any multiple thereof or to any other periodic force frequency, supports the belief that the vibration was self-induced.

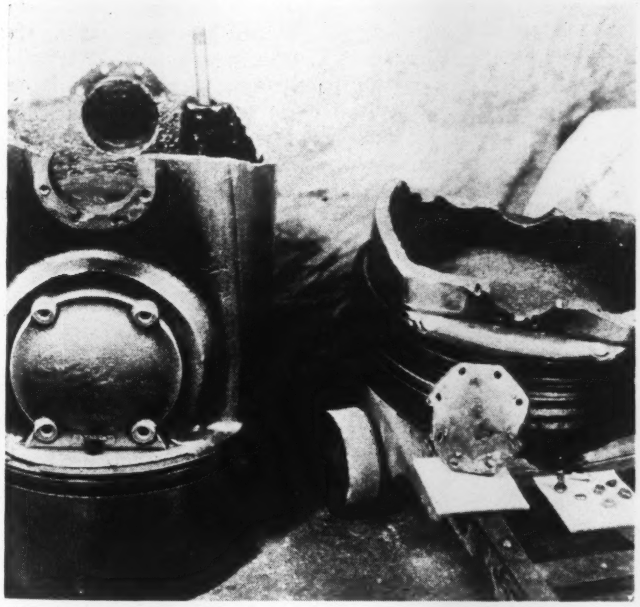


FIG. 7 ENGINE PISTON WRECKED DUE TO FATIGUE CRACK

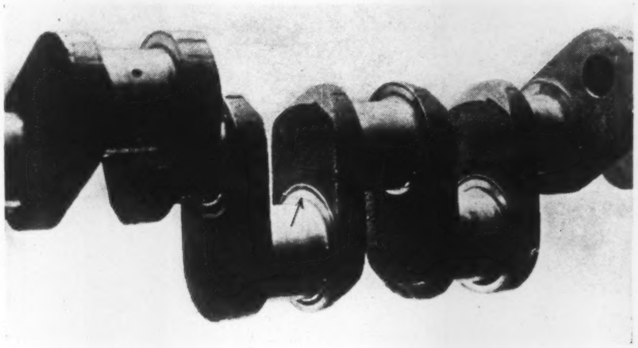


FIG. 6 CRACK IN CRANKSHAFT WEB

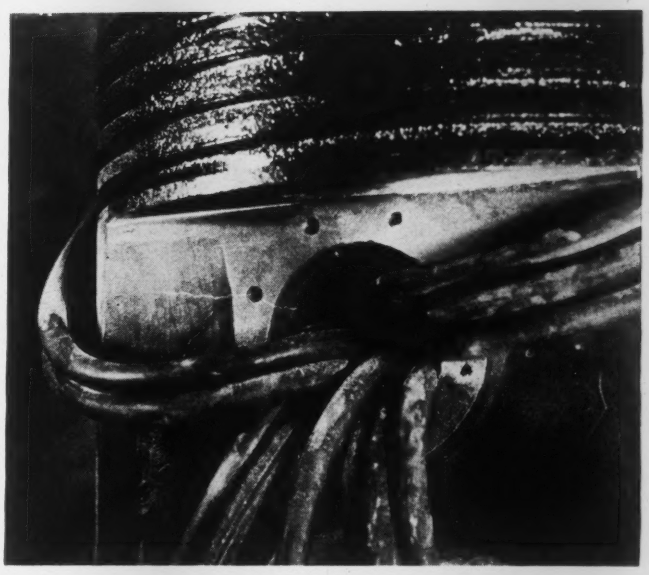


FIG. 8 FATIGUE CRACK DISCLOSED BY POWDER

Examples of the propagation of cracks by thermal stresses or cyclic movements due to temperature changes are difficult to prove, yet the growth of certain types of crack requires somesuch explanation. The Trevelyan rocker furnishes an interesting example of the manner in which a large mass can be set in periodic movement by rapid expansion and contraction due to temperature changes by conduction at a sharp contact. Although few supporting experimental data are available, some such phenomenon may cause the spread of cracks in parts subject to heat fluctuations.

FATIGUE CRACKS—THEIR PROPAGATION AND APPEARANCE

The propagation of the true fatigue crack is relatively slow. It is a function of the magnitude of the stress reversals and the number of reversals in a given time. With careful, periodic inspections, usually ample warning is given before final rupture occurs. The smaller the vibratory movement and stress-reversal range, the finer will be the surface of the fracture and the harder to detect.

The surface of the fatigue crack generally shows the characteristic shell-like markings (Fig. 1), indicating the progress and the vibration history. Sometimes, these markings are so fine that they can only be seen in reflected light at a particular angle. As the cracks progress, the section modulus at that zone changes, and, hence, the natural frequency is lowered. This may throw the part out of resonance with the disturbing force and diminish the amplitude. Foreign matter and a viscous film in a crack have restored the original natural frequency, increased the vibration amplitude, and also broadened the tuning. Often the mode or direction of vibration changes as the crack progresses. This causes the crack to deviate from a flat plane and form a curved fracture surface. Often, changes in intensity and other characteristics of the vibration can be read in the surface markings just as the annular rings in a tree section show its growth history.

After a specimen has withstood several million stress reversals without cracking, the usual assumption is that it has been subjected to stresses well below the endurance limit and should last indefinitely. However, fatigue cracks have been found in parts that had already been subjected to many billions of reversals. For example, a particular turbine blade vibrating at a natural frequency of 300 cycles per sec undergoes a little over a million reversals in an hour of running. Yet this blade failed only after four years' operation, representing 30 billion reversals, a situation frequently encountered.

A reasonable explanation is that the conditions under which the greater stresses causing fatigue occurred were only intermittent and transitory, as during the starting up and shutting down of the unit. This is particularly true of oil and steam lines affected by vibration from unbalance, which may tune in and vibrate wildly only while the unit is passing through some particular speed. Thus, years may be required to develop a fatigue crack. Turbine operators have an old saying that units kept on line longest give the least trouble.

Despite the advances made in the design and metallurgical arts toward the creation of equipment that will be failure-proof, so many factors of an accidental and unpredictable nature remain to enter the picture that no substitute has yet been evolved to replace frequent, thorough inspection.

DETECTION OF CRACKS

Years ago, the whiting test became popular for the detection of suspected but invisible cracks. By this method, the suspected area was coated with a penetrating oil, dried, and covered with a whiting mixture. The oil, seeping out of the crack, stained the whiting and disclosed the crack. When properly used, this method is still valuable, within limitations, especially for coarser, well-developed cracks. However, it is not infallible and often will not reveal cracks demonstrated by other means. It is practically useless for the fine shallow surface cracks often encountered on finely finished parts and for more extensive cracks in compression.

The acid-etch method to make the crack visible has been fairly successful, where the application is appropriate. However, a thorough job requires a polishing of the entire area suspected and sufficient time for the etching. Neutralizing with a caustic is generally required afterward. With many large-scale applications, the etching method is entirely too tedious and costly.

Crack detection in ferrous materials by magnetizing the part and applying a finely divided magnetic powder has now been in successful use for several years. The magnetic-flux leakage at even the finest crack attracts the powder in its attempt to bridge over the discontinuity and makes it visible. Three methods for magnetizing the object for inspection, each having its own field of usefulness and advantages, are available. In the first, the part is magnetized by two electromagnets, the poles of which are placed on the object to establish flux in the area being examined. This system is particularly useful for the testing of small, light parts on a production basis, but the magnets may also be used on large, stationary objects. A portable set for this purpose is illustrated in Fig. 2, complete with resistance and panel. The second method magnetizes the object by wrapping it with several turns of cable carrying a relatively heavy current. The current is usually supplied by a small, portable electric-welding set having a capacity of from 200 to 400 amp. From 500 to 2000 ampere turns are generally found sufficient, even for the largest parts. With the third method, a heavy current is passed directly through the piece under test. The application of the current need be but momentary, as the residual magnetism is usually sufficient. This method is especially advantageous for small parts on routine testing, and particularly where the anticipated flaws are in the direction of the current flow.

A magnetizing set using current is shown in Fig. 3. The

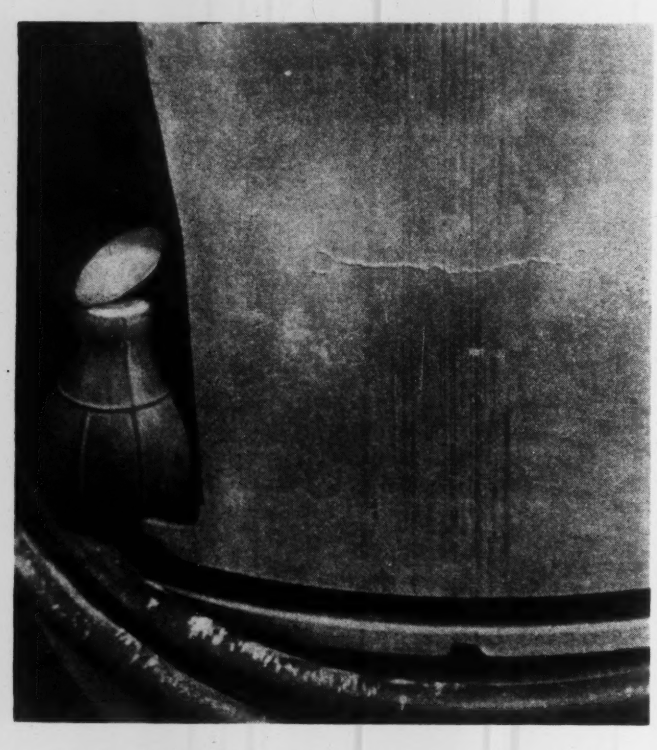


FIG. 9 OLD CRACK IN PISTON SKIRT, SHOWING PLUGGED STOPPER HOLES

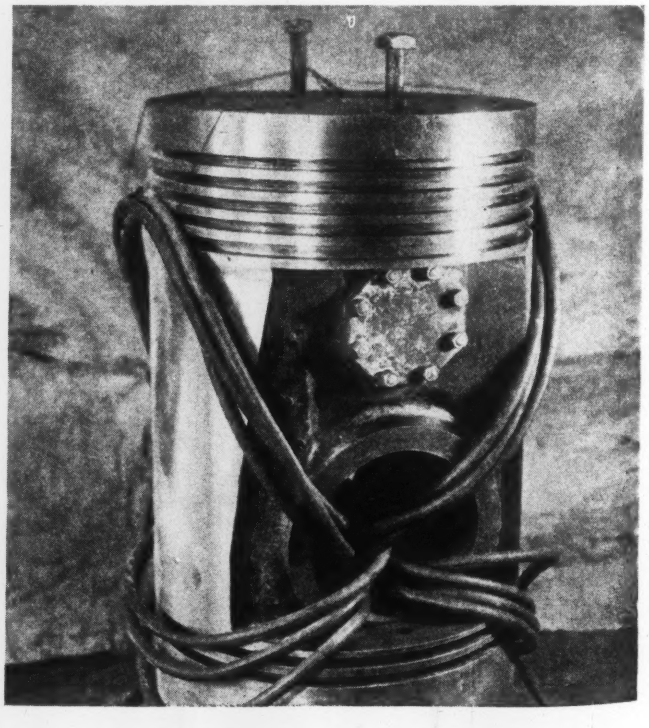


FIG. 10 PISTON MAGNETIZED BY TOROIDAL WINDING

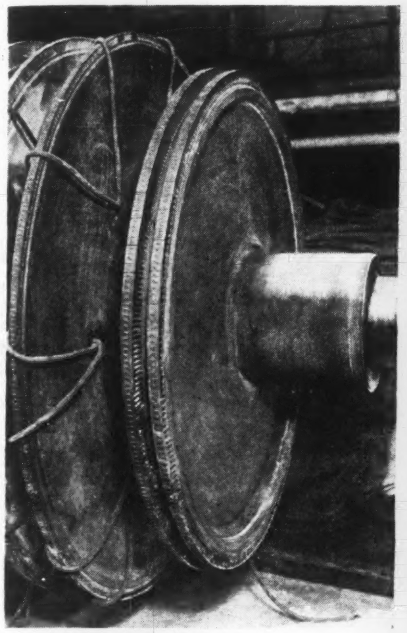


FIG. 11 STEAM-TURBINE DISK WHEEL MAGNETIZED BY TOROIDAL WINDING

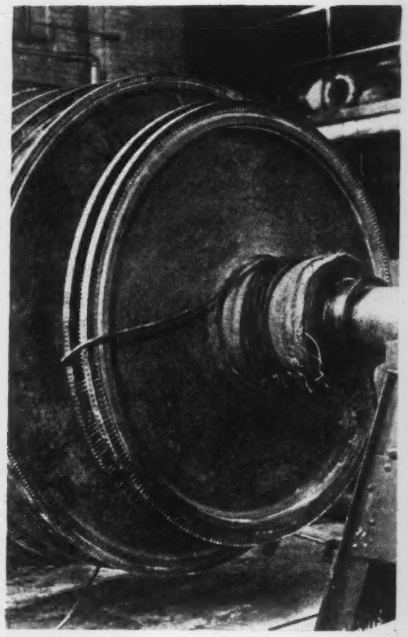


FIG. 12 TURBINE ROTOR MAGNETIZED BY SOLENOID-TYPE WINDING

piece to be tested is placed between the upper and lower electrode plates.

The magnetic powder is applied either wet or dry, as convenient, and either method is effective. The dry powder, dusted or sprinkled lightly over the surface with a shaker or a spray bulb, is best suited for covering large areas, such as castings, shafting, turbine blading, and disks. This magnaflux powder can be procured with a light greyish white coating. It dusts on readily, and the color contrast with dark surfaces makes the crack stand out prominently.

The black magnetic oxide of iron, in the form of an extremely fine, impalpable powder, is better suited for the wet method, in which a light oil is used as the carrier. Small parts can be tested by immersion in a bath of this mixture. The small magnetic particles in suspension readily collect at the crack, which shows up as a fine black line. The mixture can also be flowed on the surface of large parts, such as shafting and turbine disk wheels. The particles are mobile in the oil film and will concentrate at a crack. The black oxide is particularly suited for the detection of very fine surface cracks in polished surfaces. Fig. 4 shows a hardened and ground ring containing two cracks that are invisible. After magnetizing and treating with the black oxide powder, the cracks are unmistakably evident, as illustrated in Fig. 5.

TYPICAL EXAMPLES OF FATIGUE CRACKS

The typical fatigue crack in the web of a crankshaft due to stresses from bearing misalignment is shown in Fig. 6. The otherwise invisible crack is made evident by the line of grey powder as indicated by the arrow. Large Diesel-engine crankshafts and steam-engine shafts are easily magnetized to show up such cracks by removing the connecting rod and passing a few turns of cable around the web or crankpin.

In Fig. 7[1] is shown the wreck of a large gas-engine piston. Sometime earlier, a failure of the cooling oil in the top of the piston occurred, and the consequent heating and expansion caused a severe binding, thus setting up large reciprocating forces at each revolution until the engine could be shut down. To aggravate matters, a definite zone of weakness extended through the inspection handhole and around the skirt, due to stress raisers at the tapped holes for the flange studs and at the sharp fillet made by the shotgun boss on the interior. The accident occurred without warning during normal operating conditions, and subsequent investigation revealed definite evidence of progressive fracture.

An inspection for cracks in the remaining pistons resulted in the rejection of four. In Fig. 8, a true fatigue crack is disclosed by the white magnaflux powder, in the exact location where the wrecked piston was fractured. This crack could not be seen by the eye alone and probably would have escaped detection by the whiting method.

On another piston, an old crack was disclosed by the test, as shown in Fig. 9. Although this defect was invisible and unsuspected by the operators, its existence must have been known sometime earlier, as the drilling and plugging at the ends of the crack to stop its progress were plainly evident. Incidentally, the crack extends beyond the plug at the right.

Plugging such cracks may only serve to aggravate matters. The crack may extend a considerable distance beyond its visible end or the end as located by whiting. If the hole is not drilled beyond the extreme end, it is useless. If such a hole is plugged, the drifting or wedging action may only make the crack spread more rapidly. The magnaflux method is valuable in determining the true limits of a crack which can be arrested by a stopper hole. If possible, the crack should be rigidly bound together at the middle by shrink links or other means, to prevent further "working," as this movement causes the crack to spread. The movement required to start a fatigue crack is surprisingly small, even truly microscopic.

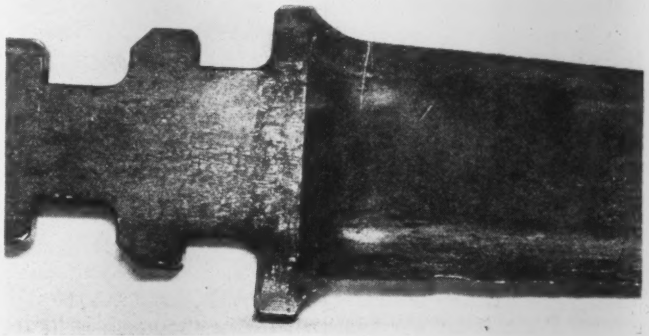


FIG. 13 CRACK IN STEAM-TURBINE BLADE DISCLOSED BY MAGNAFLUX POWDER

PITFALLS TO BE AVOIDED IN CRACK DETECTION

Merely to magnetize the object, sprinkle powder, and watch for cracks is not sufficient in carrying out a magnaflux test. Pitfalls must be guarded against, lest cracks that do exist es-

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[1] Photographs of Figs. 7, 8, 9, 10, and 14 are the work of Ayres A. Stevens.

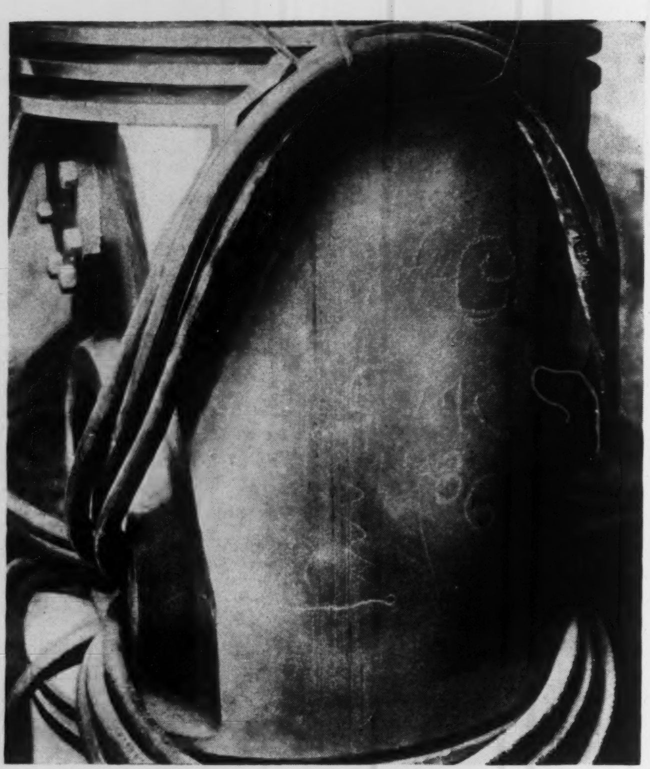


FIG. 14 "MAGNETIC WRITING"

cape detection, or false indications of cracks and flaws that do not exist cause the object to be needlessly condemned or mutilated.

Although the magnetic-powder test method has now been in successful use for several years, its earlier application has been largely limited to small objects easily magnetized in a proper manner. Considerable experience has recently been acquired on larger and more complex parts which indicates that with proper attention to certain fundamental rules in magnetizing, full confidence may be placed in the inspection for cracks.

Mere strength of magnetic field does not insure the disclosure of a crack—in fact experience has shown that, under certain conditions, too much flux density is objectionable. That the direction of the flux lines be that best suited to show up the crack is far more important. If the crack is located at a pole where the lines come out at right angles, the powder has no way of knowing that a crack exists, as its function is to bridge the leakage at a crack.

As a specific example, a circumferential crack in the skirt of the piston shown in Fig. 10 would not attract the powder when the piston was magnetized by wrapping the cables in solenoid fashion at one end. The reason was evident when it was found that, due to the conformation of the casting, the flux lines were forced out at right angles to the surface at that point. When the piston was properly magnetized to avoid poles at the surfaces being examined, the cracks readily attracted powder from some distance away in the air. Incidentally, the strength of the field required was reduced to a very small value. The type of wrapping used is called the toroid method and is similar to the winding on a doughnut-shaped core because it produces a closed flux circuit.

The application of the toroidal winding to steam-turbine disk wheels is shown in Fig. 11. By this method, the flux lines are largely circumferential, and the most minute cracks having any radial component are readily disclosed. Even circumferential cracks are sufficiently irregular to have some radial component.

In Fig. 12 the solenoid method of wrapping is shown, which is especially suited for detecting cracks and flaws in the shaft itself.

Certain other methods of wrapping, in the attempt to favor the circumferential type of crack, had the effect of forcing the lines of flux out at right angles to the surfaces of the disk. The powder merely flew directly to the surface and stuck there in streamers, regardless of the presence of a discontinuity.

Fig. 13 shows a crack in a large turbine blade that was made visible by the magnaflux powder. One of the most effective fields of usefulness for this kind of test lies in the detection of cracks in steam-turbine blades and buckets, which are so prone to be invisible to the unaided eye. The author's first experience with this method of inspection was in connection with a research on blade failures that was being carried out a number of years ago at the South Philadelphia works of the Westinghouse Electric & Manufacturing Co. The method soon demonstrated its value and, in addition to its use in the field, was made a part of the shop inspection routine. At first the blades were checked individually, then methods for inspecting an assembly in the rotor in the field by electromagnets were developed.

Puzzling markings, where the powder indicated flaws or cracks which were found not to exist, have been encountered in the past. As a matter of interest, Fig. 14 is included to show how some of these markings come about. The hieroglyphics are due to the powder collecting on spots at which local residual magnetism has been set up by simply drawing a piece of iron rod along the magnetized surface. To prove that such marks are false, reverse the polarity, which produces a "negative" mark; that is, the powder falls away from the mark and clings to the sides. A number of other conditions exist which might give false indications without sufficient experience.

A crack discovered in the front axle of a racing car just before a recent automobile race is shown in Fig. 15. The magnetization in this case was accomplished by passing a heavy current directly through the part. This crack is absolutely invisible to the unaided eye. Apparently the sharp fillet at the junction of the stub axle and the bracket set up an excessive stress concentration. The discovery of this crack probably saved the driver's life.

From the examples described, the magnetic-test method is seen to be applicable to practically all types of machinery and their individual parts. Properly used, it has proved to be an extremely valuable tool in the inspection of equipment insured by our company.

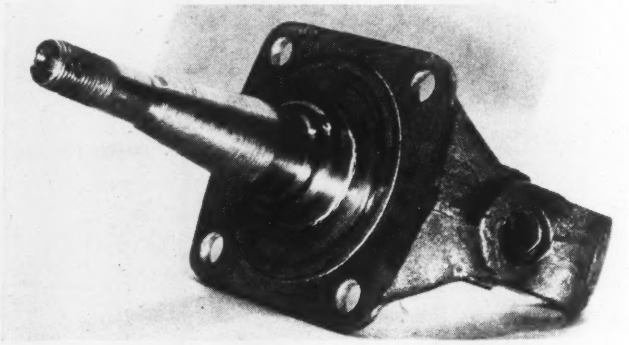


FIG. 15 CRACK DISCOVERED IN FRONT AXLE OF RACING CAR

MAGNAFLUX INSPECTION *of* BOILER DRUMS *and Unfired* PRESSURE VESSELS

By R. F. CAVANAGH

ENGINEERING DEPARTMENT, FIDELITY & CASUALTY CO. OF NEW YORK

The nondestructive magnetic-dust method of discovering invisible cracks and defects has been successfully applied to steam boilers and unfired pressure vessels. This dust is manufactured by the Magnaflux Corporation and is generally known as magnaflux powder. It is basically metallic iron that has been finely ground to pass a 100-mesh sieve. The individual particles are spindle-shaped rather than globular to obtain the better polarization which facilitates their grouping or arranging at a crack or defect. This grouping is facilitated by specially coating the particles to prevent rusting and to add lubricating and insulating properties that retard packing and sticking. When dry, the powder particles are effectively insulated from each other electrically. An infinity megger reading should be obtained even with the electrode terminals buried only a fraction of an inch apart in a can of powder.

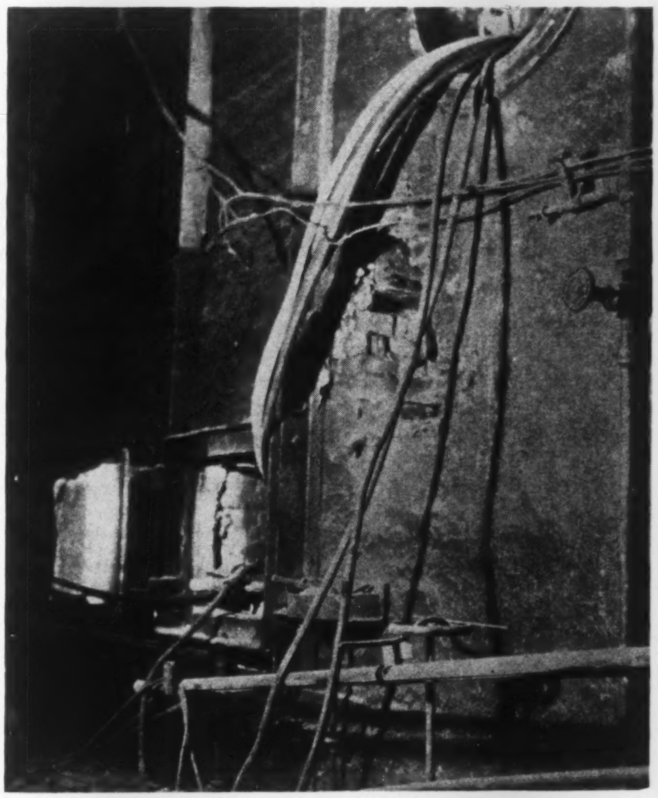


FIG. 1 MAGNETIZING MULTIPLE-DRUM WATER-TUBE BOILER BY PASSING CABLES THROUGH TUBES OF ONE DRUM AND BACK THROUGH MANHOLE OPENING OF SECOND

In applying the powder, the best results are obtained by using a common bulb spray, such as is used for spraying powder on plants, with a perforated aluminum nozzle that is set at an angle. When using the powder in a confined space, an approved type respirator is recommended to prevent possible irritation of the mucous membranes or the eyes.

The bulb should not be filled to more than half of its capacity. For vertical and particularly for the underside of horizontal surfaces, practice will enable the operator to "lay" the powder in place, by a combination of throwing and light rapid squeezing of the bulb. Best results are obtained when the small puff of powder just reaches the surface under investigation. If the air blast is too hard, the powder is likely to be blown from any defect that may be present. For horizontal surfaces, sufficient powder is dispersed by giving the bulb a slight shake.

By carefully observing the factors involved, a fairly accurate estimate of the depth of a crack can be made. The variation in the quantity of powder adhering to the crack corresponds with the variation in its depth.

To permit proper inspection, all interior and exterior seams must be exposed and made accessible for examination either directly or with a mirror. The seams should be wire-brushed and any thick scale or sediment removed. A perfectly clean bright surface is not necessary, as the powder will reveal cracks through a light scale or rust coating, but all loose rust or scale should be removed.

Where riveted seams are used, some rivets should be removed to permit detailed examination of the rivet itself and the sides of the hole, especially the shell plate between the inner and outer butt straps. Ordinarily four or five rivets are removed from each longitudinal seam and two or three from each girth seam. Those rivets are selected for removal which show indications of past leakage or repeated calking. Removing at least one rivet near the bottom of each girth and head seam is also advisable.

Unlike the magnifying and photographic methods that require careful polishing and etching in and around the rivet hole to make cracks visible, the magnaflux method requires no preparation of the hole. If a crack is there, the powder will make it visible to the unaided eye several feet away.

Boiler shells or drums are magnetized by winding several

Presented at a joint meeting of the New York Section of the American Welding Society and the Metropolitan Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Jan. 13, 1937, New York, N. Y.

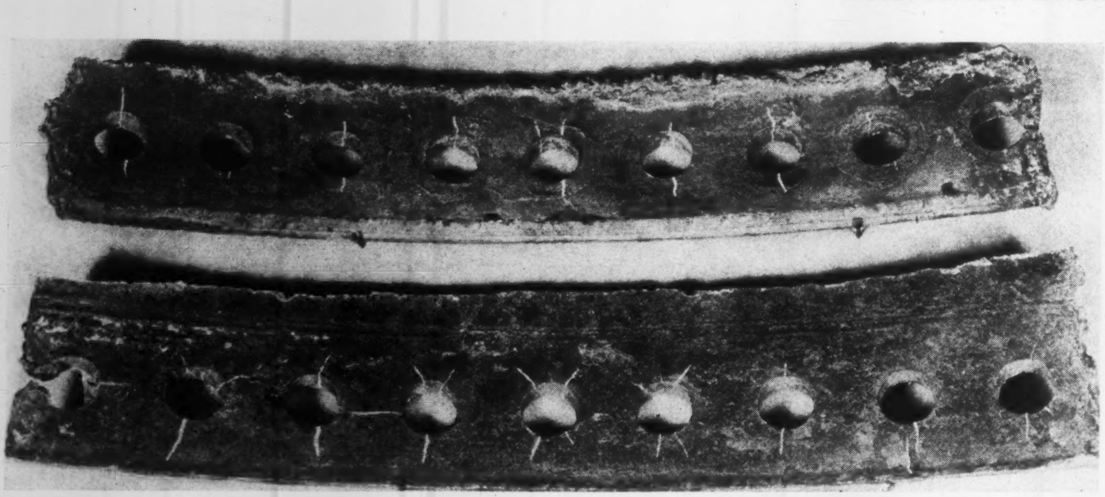


FIG. 2 TYPICAL EXAMPLE OF CAUSTIC-EMBRITTLEMENT CRACKS IN GIRTH SEAM OF HORIZONTAL TUBULAR BOILER

turns of flexible cable through or around them. The cable is energized by an ordinary portable electric welding set. The current value is dependent on the size of the shell or drum and the number of turns of cable, the average being about 2000 ampere turns. For multiple-drum water-tube boilers, a convenient method is to wind two drums at one time by passing the cable across through circulating tubes and out the manhole opening of the second drum (Fig. 1).

Where each end of a boiler drum or shell has a manhole opening, the cable is wound longitudinally through the manhole openings and around the outside of the drum, and, in some cases, winding the cable circumferentially around the shell or drum is more convenient. In general, a magnetic field should be set up within the shell or drum at right angles to the direction in which cracks or defects are expected to be found. However, most cracks running in the general direction of the lines of flux present sufficient transverse components to prevent their escaping detection. Where incipient cracks of microscopic dimensions are being searched for, magnetization in both directions is necessary.

Winding shells or drums longitudinally is usually more convenient, and, in addition, the flux direction will be the most favorable for investigating the greatest area. As this flux direction will be less favorable for detection of circumferential cracks, investigation in that direction can be conveniently made by portable electromagnets.

Portable electromagnets are also used where magnetization in the desired direction is not practical by the cable-winding method. For the head seams, one magnet is placed on the head and the other on the shell in a radial line with the first and approximately 1 ft away. A similar setup is effective for other girth seams. The magnet poles on either side of the seam should, of course, be checked. Portions of the drum of a water-tube boiler farthest from the coil, particularly drums with blank heads where the cable has been passed through tube holes instead may not have sufficient flux density. In such cases, portable electromagnets can generally be used to cover these local areas.

The best method for determining whether the flux density is sufficient is to observe how the powder collects at the edge of the rivet head against the shell or strap, as this, so far as the powder is concerned, is a crack. With some practice, the manner in which a light dusting of powder clings to any surface or edge will indicate whether the magnetization in the right direction is sufficient.

Generally the tendency will be to overmagnetize rather than undermagnetize the drum. Often, the residual magnetism after shutting off the current is sufficient to show up cracks. If the flux is too great or flux lines come into the air at right angles, the powder will fly directly to the surface and collect in "streamers" or hairs that stand out from the surface. Cracks will then not show up properly. In such cases, the residual-flux way gives best results, particularly for those portions of the head inside the loop.

Cracks are sometimes caused by the local concentration of stresses that are set up by breathing action or thermal expansion and contraction. This type of crack follows the general behavior of fatigue cracks, often preferring a surface notch, such as is provided by the rough surface or porosity of a poorly laid bead of weld, for its starting point. The general subject of fatigue cracks is discussed by T. C. Rathbone in another paper in this issue. (See pages 147–152.)

CAUSTIC OR HYDROGEN EMBRITTLEMENT

All cracks radiating from a rivet hole are not necessarily embrittlement cracks, and recognized authorities are not in agreement as to what is or is not embrittlement. The most reliable information indicates that cracks may start at local areas that are stressed beyond the yield point in the presence of a concentration of caustic, silica, and heat. By some mysterious process, nascent hydrogen, which is liberated by oxidation

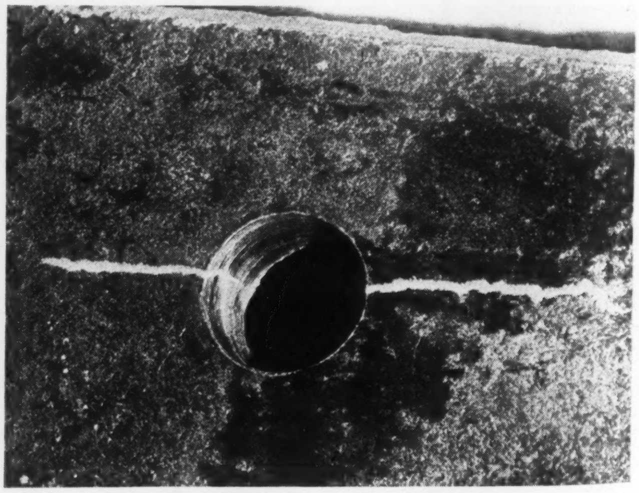


FIG. 3 CRACK IN $^{15}/_{16}$-IN. PLATE FORMING SHELL OF DIGESTER

under these conditions, has the power to penetrate the intercrystalline cementite and cause cracks.

Many cracks found at rivet holes by magnaflux were definitely not embrittlement cracks but were caused by mechanical processes, such as excessive drifting and riveting pressures in manufacturing, excessive calking, or by fatigue from breathing. Microscopic examination of the crack with suitable etching reagents may disclose its origin, but here again some confusion exists, as examples of embrittlement cracks are found transversing the crystals instead of being intercrystalline, and portions of stress-fatigue cracks may follow crystal boundaries instead of being transcrystalline.

Generally, irregular, branching and discontinuous cracks that radiate in all directions, pass each other, and form islands, are indicative of embrittlement, especially where caustic concentration is found between plates. Stress cracks, on the other hand, have a general tendency to progress in a more direct line and usually are not as numerous, sometimes occurring as a single crack between rivet holes.

Fig. 2 is an example of embrittlement cracks that occurred in the girth seam of a horizontal tubular boiler which was found to be a typical case of caustic embrittlement. This boiler had been in service less than four years, was built according to the requirements of the A.S.M.E. Boiler Code, and received the required inspection during construction. It was of butt and double strap, quadruple-riveted seam construction. The condition was obviously caused by improper feedwater treatment.

Fig. 3 shows part of a 5 × 20-in. plate that was cut from a $^{15}/_{16}$-in. shell plate of a hammer-welded digester, which was 8 ft in diameter and 25 ft long and operated under a pressure of 110 lb. One crack, more than 14 in. long and reaching the maximum depth of $^{3}/_{4}$ in. was revealed by magnaflux on the interior surface. This crack was not visible under a four-power magnifying glass. Several smaller cracks were also found. Imperfect seams in this digester were easily demonstrated by magnetizing with portable electromagnets. Here, the thin edge of the scarfed joint had either chilled or else scale prevented making a perfect bond.

The extent of the imperfect seams and the cracks were investigated further by trepanning to obtain a small coupon. This investigation confirmed the previous estimate of the depth of the cracks, and also revealed that they were caused by caustic embrittlement.

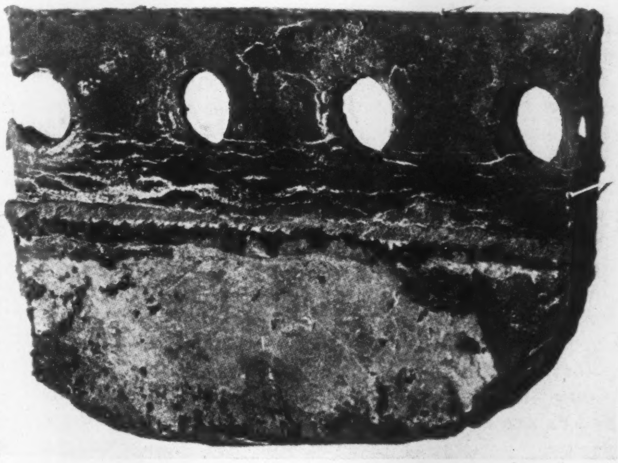


FIG. 4 PART OF PLATE FORMING GIRTH SEAM OF HORIZONTAL-RETURN TUBULAR BOILER

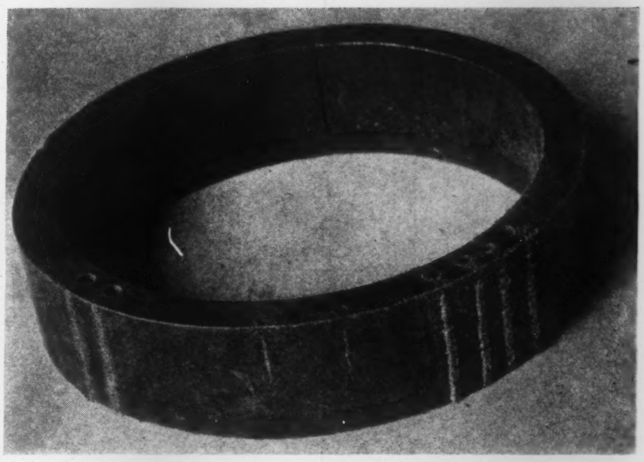


FIG. 5 EXAMPLE OF DETECTION OF HIDDEN DEFECTS BY MAGNAFLUX PROCESS

Magnaflux inspection was immediately made of the other two digesters in this particular plant, after the conditions previously mentioned were disclosed, and they were found in practically the same condition. All three were condemned for further use as pressure vessels and were immediately replaced by new ones.

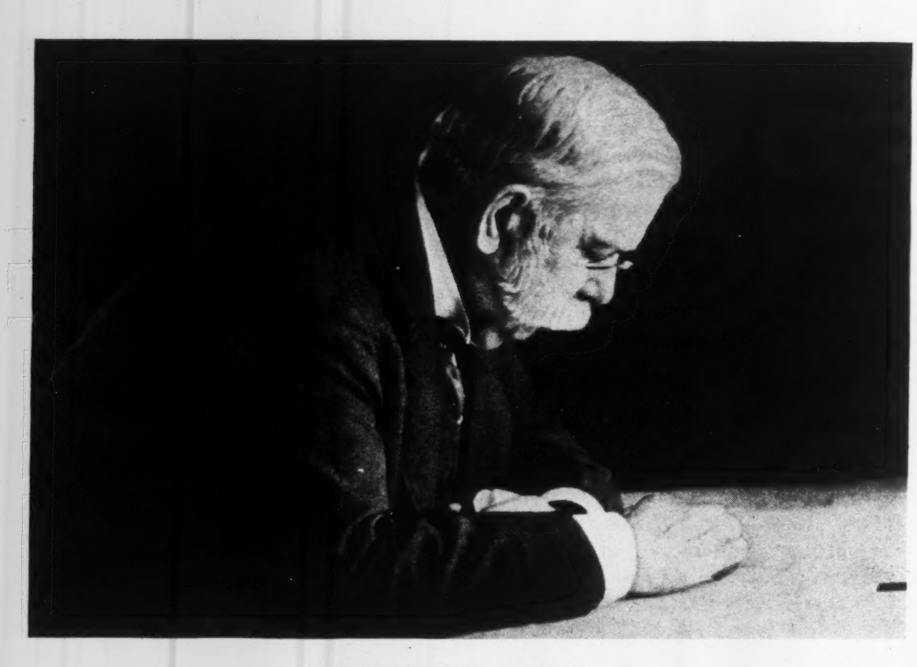
OTHER TYPES OF DEFECT REVEALED

Fig. 4 shows a piece of plate taken from the girth seam of a horizontal fire-tube boiler. In this case, the operator of the boiler laid a bead of weld along the seam, thus forming a fillet on the inside to stop leakage. The large cracks at the weld had developed through to the outer surface, and a bead of weld 6 in. long had been applied to seal it. A magnaflux test revealed that the crack continued intermittently for 20 in. At some points, the larger crack penetrated to within $^{1}/_{32}$ in. of the outer surface of the plate. While this method of repair could not be approved, the test did prove conclusively that the crack was considerably longer than could be detected with the eye.

Cracked ligaments are frequently found in the top tube sheet of the waste-heat type of vertical fire-tube boiler that is used in connection with the manufacture of water gas. The flame or hot gases are applied in periodic cycles recurring every few minutes. This sets up a cyclic expansion and contraction or breathing which is very conducive to the start and propagation of cracks. Usually such cracks have been repaired by welding. New cracks often develop subsequently alongside the weld, due to improper annealing and continued breathing. On one occasion of this type, nearly fifty cracked tube-sheet ligaments were found, which, had they progressed farther, would have freed a section of the sheet with its tubes.

Nozzles and fittings on digesters and other pressure vessels of the welded type cannot generally be X-rayed satisfactorily. The magnaflux process is, therefore, particularly useful for this application as the powder will collect over flaws or voids in the weld even when these defects are considerably below the surface.

One of the outstanding advantages of this over other methods adaptable to field investigations is its ability to reveal flaws and other defects beneath the surface of the material faithfully. The ring in Fig. 5 was prepared by drilling holes of several different diameters in the ring and at different distances from the outer edge of the ring. Applying the powder very clearly outlines these holes on the surface of the ring.



WESTINGHOUSE AT WORK

GEORGE WESTINGHOUSE *the* MAN

By PAUL D. CRAVATH

I HAVE reached that unfortunate age when frequently recurring semicentennials are a constant reminder that I have been on the stage of life beyond the alloted span of three score years and ten. This year happens to be the fiftieth anniversary of the beginning of my association with George Westinghouse. He was my first important client, and my association with him until a short time before his death was very close and intimate. I confess that on this occasion, when most of you who had no close personal contact with Mr. Westinghouse are thinking of the inventor, it is the man, and not the inventor, that dominates the memories of my long association with him, so that the topic you have assigned to me fits in with my mood.

I first met Mr. Westinghouse in the fall of 1884 when I stopped off at Pittsburgh on the way from my home in the West to begin my training for the bar in a law school in the East. I shall never forget the graciousness with which this busy man interrupted his work to talk with me, a callow youth of whom he had never heard; nor shall I ever forget the impression of simplicity and radiating energy that he made upon me.

Whenever I visit the great works of the Westinghouse Electric Company at East Pittsburgh, I am reminded of my second meeting with Mr. Westinghouse. It was in the fall of 1886, in the Company's little shop, which then occupied one floor of a small building in Pittsburgh. I remember, as vividly as though it were yesterday, the enthusiasm with which he spoke even to a humble visitor like myself, of the unbounded possibilities of electricity applied to the service of man and, more especially, of the great destiny of the alternating current.

It was soon after that, when Mr. Westinghouse with characteristic courage and breadth of vision, had chosen the largest city in the country in which to demonstrate the superiority of alternating current for central-station lighting that he acquired control of the high-tension electric-lighting enterprises in New York which were destined to play so important a part in the development of his plans. It was as counsel for those enterprises that I began my association with Mr. Westinghouse—an association that was destined to become the most absorbing and inspiring relationship of my life. For twenty-five years my relations with Mr. Westinghouse were most intimate.

During that period, in my humble rôle, I worked at his side in the development of his electrical enterprises which, after the successful establishment of the Air Brake Company, absorbed the major part of his energy and interest. I saw him thus intimately under almost every conceivable condition—in his home, at his office, in his factory, in his private car which was almost another home, abroad, as well as in this country. I saw him when he was elated by successful achievement, and amid disappointments and discouragement, and more than once in the face of threatening disaster. I saw him when he was carrying a load of responsibility under which any other man whom I have ever known would have fallen. He was always the same; simple, unassuming, direct, frank, courageous, unfaltering in his faith, and supremely confident in the ultimate triumph of his plans. I have seen him wearied almost beyond endurance; disappointed beyond expression over some miscarriage of his plans; wounded in his feelings because he had discovered stupidity where he expected intelligence, discouragement where he had expected encouragement, disloyalty where he had a right to expect loyalty. I have seen him more than once when every man about him despaired of his being able to attain the ends for which he was striving and advised surrender or compromise, but I have never known him to acknowledge defeat nor to

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yield to discouragement, nor to falter in his efforts to accomplish his main objectives.

Comparing George Westinghouse with the other men of his generation who acquired conspicuous positions in the world of industry and finance, it is my considered judgment that no man I have known combined so many of the qualities that make for greatness. The qualities that constitute genius in a human being defy definition. Judged by the standards that I am able to apply, George Westinghouse was a great genius. I assume that all will agree, indeed, the world recognizes, that he was a genius in the field of invention and mechanics. It would be unbecoming for an ignoramus like me to discuss in this presence this phase of Mr. Westinghouse's genius.

A GREAT INVENTOR, ORGANIZER, AND FINANCIER

Besides being a great inventor, Mr. Westinghouse was a great organizer. Perhaps in his lifetime this assertion would have been questioned by some. I do not see how it can be questioned now. Remember that I am attributing to him as an organizer the qualities of greatness, and not the quality of superficial efficiency. He undoubtedly had the faults of his qualities. Every great man has. Judged by standards of temporary efficiency and by immediate results, his methods of organization sometimes seemed unsound. They were often irritating to his associates. He was apt to be careless of immediate success and to look far ahead for ultimate results. He had the strength of character and the wisdom to submit to temporary inconvenience and to sacrifice temporary advantage to achieve his ultimate ends. Now that we can begin to look back upon Mr. Westinghouse's achievements as an organizer with some approach to the perspective of the historian, we must agree that as an organizer, Mr. Westinghouse manifested qualities of real greatness. Not always unerring in his choice of men, he was always sound in the selection of the fundamental principles which underlay his method of organization. He was a great personal leader, and inspired devotion and affection among his fellow-workers of all ranks. By his own boundless industry and energy he set an example of vigorous and untiring effort that vitalized all the organizations of which he was the head. Every enterprise that he created was built on foundations that were essentially sound and strong. Those foundations have proved able to carry the enormous structures that only his vision was able to foresee.

It is a sad commentary on the limitations of human wisdom that the full fruition of Mr. Westinghouse's plans as an organizer came only after his death. The great enterprises that he founded, some still bearing his name, others transferred to different affiliations, are today achieving signal success along the lines that he laid down, and in the main by men developed under the inspiration of his leadership. He was the soul of the enterprises that he created. That soul is immortal. It still goes marching on, and will forever animate the enterprises upon which almost a half million people depend for their livelihood—enterprises that are all devoted to increasing the comfort, safety, and happiness of the world. Has any organizer of our day left a comparable record? Is there any other for whom posterity can make so convincing a claim for qualities of true greatness?

Besides being a great inventor and a great organizer, Mr. Westinghouse was, in my estimation, a great financier. This claim would have been questioned by many during his lifetime—some would doubtless question it now. I prophesy it will not be questioned by posterity. I don't say that he was a prudent financier, especially if judged by the standards of Wall Street or of orthodox banking circles in Pittsburgh, but I do claim that he was a great financier. If he had been what we are pleased to call a prudent financier he probably would not have been a great one.

Let us analyze Mr. Westinghouse's claim to greatness as a financier. He was a pioneer in at least four important fields of industry. His enterprises from their very nature required enormous capital. Several, indeed all, of his enterprises were of such character that long periods of experiment and development necessarily preceded the ultimate success that would yield profits. Capital for enterprises of that character, which could not show an earning statement, was difficult to obtain, and yet Mr. Westinghouse, starting life without capital of his own, was able to obtain almost unaided, by the sheer force of his faith, by his power to inspire confidence, by the qualities of his genius, the enormous sums required for the development of his enterprises. He rarely numbered among his close associates important financiers or wealthy men. This may have been a fault, but it was a limitation growing out of the very qualities of his genius. He found it difficult to work with so-called financiers. What seemed to him to be their lack of vision and faith was always galling to him. While he often tried to work in concert with strong financial associates, he usually found himself in periods of financial stress, compelled to rely upon his own energy and his own resourcefulness. In at least two great financial crises, when the financiers had given up the task as hopeless, Mr. Westinghouse, by his faith, by his untiring energy and by the exercise of a power to influence men that I have never seen equaled, was able to weather the financial storm, raise enormous sums of money, and restore his enterprises to a sound financial position when his critics and most of his friends were certain that he was facing a crushing defeat.

It was inevitable that a man of George Westinghouse's courage and boldness should suffer financial setbacks; but he never suffered financial defeat. Today all the enterprises that he founded are sound and prosperous. Their financial structures are of his building. Those structures rest upon the sound foundations that he laid. These enterprises, employing as they do, not far from a quarter of a billion dollars of capital, were financed by Mr. Westinghouse almost unaided and often in the face of discouragement and opposition. They constitute the monument to his success as a financier. I say, therefore, that he was a great financier, and I prophesy that that will be the verdict of history.

In all these fields of endeavor—as an inventor, as an organizer, and as a financier—judged by the standards that I am able to apply, I think he was a great genius. In each field he combined beyond any man I have ever known, the qualities that seem to me to go to make up genius. They are mental energy, imagination, faith, courage, and character. These qualities were combined in George Westinghouse to a remarkable degree. Any man who has been his business associate for a quarter of a century has often seen him under circumstances that required the exercise of all these qualities. A man who lacked any of them could not have carried the burden in the face of discouragement and opposition that so often rested upon his shoulders.

IMAGINATION, FAITH, AND COURAGE MADE HIM A GENIUS

The qualities of George Westinghouse which, it seems to me, gave him the supreme quality of genius, were the qualities of imagination, faith, and courage. We know many men of great mental vigor; we know many men of strong character. Those qualities are, of course, the background of any successful career, but I am sure none of us has ever known a man who combined the qualities of faith, imagination, and courage as they were combined in George Westinghouse. Those who are familiar with his enterprises are constantly finding new evidence of these qualities. A very interesting—almost dramatic—instance came to my attention in London during the last year of the War. I presume that most of Mr. Westinghouse's associates would look upon the British Westinghouse Electric Company as one of his failures. In one sense it was a failure, yet the conception out of which that enterprise grew was the conception of a great man, whose vision, imagination, and courage carried him beyond the limits of prudence and business discretion.

During the European War, one of the strongest groups of business minds in Great Britain determined to enter the electrical field. They purchased the British Westinghouse Electric Company. One of these men asked me to spend an evening with him and a few of his associates to give them such information as I could about the early history of the enterprise. Their leader asked me to explain to them the reasons that prompted Mr. Westinghouse to organize the British Westinghouse Electric Company and build the immense works at Manchester, which until the outbreak of the War were much larger than the business which the Company had been able to secure would justify. I tried to give Mr. Westinghouse's conceptions as I remembered them; that the high-tension alternating current was sure to become the foundation of all central-station development; that England was an ideal field for the extensive use and distribution of electricity; that most of the British railroads had such a dense traffic as to be practically suburban roads according to American standards; that the most economical method of providing electrical power for the United Kingdom was by the establishment of generating stations near the coal mines so that instead of distributing coal, electricity would be distributed; that instead of many central stations scattered all over the country there should be a few at strategic locations; that as the financial structure of the railroad enterprises of Great Britain was such that they would find it difficult to raise new capital, there should be separate organizations separately financed, for developing the electrical power and selling it to the railroads. When I had finished my story, the leader of the group turned to his associates and said with real emotion: "This is most remarkable. The vision of Mr. Westinghouse is almost word for word our vision. The plans he formed are almost identical with the plans we propose to carry through." Then he turned to me and said: "Mr. Westinghouse's conception of what should be done was faultless. It was his misfortune that he underestimated the force of British conservatism, and was a quarter of a century ahead of the times. If Great Britain had accepted his advice, countless millions of waste would have been saved. It will now be necessary to scrap enormous investments in uneconomical plants to make way for the carrying out of Mr. Westinghouse's plan." He added that so conservative, so slow to adopt new ideas are the British people that even today the Government would be compelled to apply the spur of legislation to force the adoption of the measures which were proposed by Mr. Westinghouse a quarter of a century earlier. When he finished, I said: "You must agree, gentlemen, that while Mr. Westinghouse may not always have been a prudent man, he was a great man." "Yes," said their leader, "Mr. Westinghouse was a great man."

In what I have said I have dwelt, as it is proper that I should dwell, upon Mr. Westinghouse's qualities of greatness, for his former associates are anxious that the world should recognize, as it surely will, those qualities in the man who for so many years we were proud to call our chief; but I am sure that those of you who were his coworkers, will find yourselves tonight thinking not of the man of genius, but of the simple, unaffected, loyal friend whom we used affectionately to call, "The Old Man;" who was never too deeply absorbed to say a word of kindness and encouragement to an associate or subordinate; never so engrossed in his great achievements that he did not have time to help a friend who needed his help. It would seem profanation if I attempted by any words of mine to add to the brightness of the image that memory has implanted in our hearts. After all, was it not the finest thing about Mr. Westinghouse, man of genius as he was, that he retained from the beginning to the end of his career of great achievement, that simplicity and genuineness of character that endeared him to all his associates? I need not say to them that we shall never see his like again.

WESTINGHOUSE MEMORIAL
SCHENLEY PARK
PITTSBURGH PA

Achievements of WESTINGHOUSE *as* FACTORS *in Our* MODERN LIFE

By JAMES R. ANGELL

PRESIDENT, YALE UNIVERSITY

IT IS WITH no little hesitation that I have accepted the invitation to speak tonight concerning the distinguished man whose ninetieth birthday is being here honored. I never had the pleasure of meeting him and I am not myself an engineer. These circumstances constitute no small handicap in the effort to deal intelligently and justly with the subject upon which I have been asked to speak.

My disposition to accept the invitation has been stimulated in part by my intimate acquaintance with not a few of the leading men upon whom Mr. Westinghouse leaned at one time and another in the development of his great enterprises, and in part by reason of the fact that the thoughtful layman finds himself so completely immersed in a civilization which owes much to men like Mr. Westinghouse that on occasion his voice may properly be heard when efforts are made to evaluate the implications of engineering achievements upon the flow of human history.

PERSONAL QUALITIES

The career of Mr. Westinghouse has more than once been dealt with by persons who knew him intimately and watched his development from a simple country boy to one of the great leaders in the industrial world. The portraits which have thus been drawn all agree in setting forth a man of robust integrity of character, of great essential modesty, and of extraordinary powers of unremitting toil. It does not appear that in his boyhood he gave any evidences of intellectual brilliancy. One rather gathers that such qualities were entirely missing, but that from early childhood on he disclosed the inclination to devote his entire time and energy to problems which interested him and only to such, most of them evidently being of a mechanical nature. Certainly it seems to be clear that throughout his life his outstanding successes were the results of indomitable energy, of incessant labor, and complete inability ever to be discouraged. He seems also to have disclosed rather early in his career the qualities so essential in the promotion of new ideas in the commercial and industrial world, to wit, the power to intrigue influential men with his plans and to persuade them to take up with his ideas. The one outstanding failure in this respect was perhaps his inability ever to induce his own father to give much support to his early ventures. This is probably one of the many conspicuous instances in history of the prophet being without honor in his own country. Furthermore, it is always difficult for parents to take quite seriously revolutionary ideas proposed by their children.

MAJOR ACHIEVEMENTS

Those who are best fitted to judge seem fairly well to agree on the half dozen outstanding accomplishments by which Mr. Westinghouse is likely to be longest remembered. So far as concerns the general public, the invention and perfection of the air brake easily stands first and this despite the fact that he had been preceded in his idea of using air for this purpose by at least one other inventor, to whom, however, he owed nothing whatever, so far as is known. If his biographers are correct, Mr. Westinghouse himself was disposed to agree with certain authorities in the railroad world that his invention of the friction draft gear applicable to the speed control of railway cars was of even greater importance. Certainly the device was extremely ingenious and without it the great trains which we use on our American railroads could not be operated with safety. But the same thing is, of course, equally true of the air brake. To this same portion of his contributions to rail transportation belong his inventions of devices for power signaling and for interlocking switches. No modern rail system could possibly operate without these indispensable aids to safety, speed, and convenience.

His early interest in the rotary engine, issuing finally in his epoch-making development and introduction of the steam turbine, must rank high in any list of his achievements. Similarly his championship of the use of the alternating current, with its extraordinary advantages for long-distance transmission, together with the development of the induction motor and of apparatus which enabled alternating to be converted into direct current, where that form of electrical energy is preferable, so critical for both the financial and the engineering success of the Westinghouse program, marks one of the outstanding accomplishments in the last century of engineering progress. And these things were done in the face of the most powerful and bitter opposition.

While Mr. Westinghouse has not in the public eye been so intimately connected with the development of the gas engine as with some of these other successes already mentioned, this was early a subject engaging his active and long-continued interest and his contributions are deeply imbedded in the industrial developments which grew up around this form of prime mover. Intimately connected with this achievement, and in part responsible for his continued sense of its importance, was his development of the use of natural gas and his inventions for its safe transfer and consumption. The list of the patents which were issued to him in the course of his long life cover an amazing variety of ingenious devices, not a few of which have had important industrial and commercial consequences, but those which I have specifically mentioned are, I think, the ones that by common consent are the most likely to carry his name down to posterity in the history of industrial evolution.

TRANSPORTATION OF PEOPLE, FREIGHT, AND POWER

While their implications extend quite beyond this zone, it is clear that Mr. Westinghouse's interests were first directed to problems of transportation, whether of people, or freight, or power, and that throughout his life all of his important accomplishments, practically without exception, had direct, or indirect, relation to issues of that character. It is perhaps

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simply an indication of the close dependence of all parts of our mechanical age one upon another that starting with this initial concern for transportation, he should have devised techniques which are significant far beyond the boundaries of their original purposes.

ATTITUDE TOWARD EMPLOYEES

While I find the biographers of Mr. Westinghouse not wholly revealing on this matter, it seems to be clear that he was always highly sensitive to the welfare of his own employees and temperamentally therefore disposed to be sensitive to the needs of the laboring population as a whole. On the other hand, he was obdurate in maintaining an open shop. He exhibited no animosity to unions or union men, when they did not try to exercise coercion, but the nonunion man who did his work efficiently stood on exactly the same level as his union neighbor. In any event, nothing is more certain than that the trend in the modern world, rather definitely confirmed in our own country by the last election, is to regard all these important effects of commercial and industrial methods on large groups of our human brothers as properly and inevitably subject to general social and political consideration.

CONTEMPORARY FIELDS

Two or three of the most important contemporary fields in which the engineer has been altering the contours of our national life were left largely untouched by Mr. Westinghouse. In two of the instances this perhaps has its explanation in the relative lateness of the pertinent discoveries. Whatever the reasons, it seems in general to be true that he did not actively interest himself in the problems of telegraphy, although he did make an interesting mechanical proposal in connection with the telephone. It happens that the first commercial telephone exchange was opened in New Haven in 1879, and in the same year Westinghouse patented a scheme with auxiliary exchanges which were automatic, and he indicated in detail the specifications for their construction. This shows his interest and understanding in a new art, and his proposal dimly forecast modern machine switching. Nor do we find that the radio or the airplane were in the focus of his immediate concern, nor photography and its most influential form, the cinema. It might have perhaps been unfortunate had these vigorously attracted his attention, for the range and variety of his undertakings were such that any large additional exploratory enterprise would have been a source of possible weakness in his organizations—to say nothing of the diversion of his own intelligence from the completely absorbing problems to which he had given his life. Nevertheless, it seems rather improbable that had certain of these developments come at a more favorable period, he would not have followed his usual practice of acquiring important patents and thereupon proceeded to develop them into the most useful possible forms. Certainly nothing is more striking in Mr. Westinghouse's career than the promptness with which he spotted significant inventions of other men and sought to bring them into the area of his own activity. Unlike not a few of the conspicuous exploiters of other men's ideas, I have yet to encounter a case in which it appears that he dealt otherwise than justly, and indeed generously, with the inventors and owners of patented devices. Moreover, it may be that his deepseated wish to be a pioneer prevented his taking up with some of these forms of inventive ingenuity, because he felt that they were already far on the way to firm establishment before he came into touch with them. In any event, in our general evaluation of Mr. Westinghouse's achievements, it is essential to recognize that to three great technological activities of our time, which seem to be most instantly affecting the patterns of life, to wit, the moving pictures, the airplane (and one may add the lighter-than-air ships), and the radio, he was in no sense a contributor.

CIVILIZATION FOLLOWS THE ENGINEERS

It is in our day and generation essentially a truism that civilization is at many of its most critical points dependent upon the accomplishments of the engineer and that the character of our culture has been repeatedly changing during the last century or two as a result of the impact of mechanical inventions upon the patterns of daily life. This impact extends not only to our dependence in matters of food, clothing, shelter, and travel upon engineering devices, but it has also entered to color the whole character of our economic, commercial, and industrial outlook. To call ours a mercantile or commercial culture is often felt to cast upon it a shadow, but whether it be thought to be an unworthy shadow or not, such a characterization is in most respects transparently correct. The inventions of pure scientists and the applications made of them by inventors and industrial engineers have fundamentally changed the fabric of human life in all but the most completely uncivilized hinterland, and, were these achievements to be suddenly blotted out, our civilization as we now have it would collapse like a pack of cards. The most casual survey of any of a great group of obvious facts exhibits the truth of this assertion. Suppose, for example, that all the processes of refrigeration were unexpectedly destroyed—the modern city would starve in a few days. Take away the devices for the mechanical supply of light and heat and these same cities would be plunged in darkness at night and would be reduced to intolerable suffering through the winter months. Take away the methods of rapid, large-scale transportation, and adequate supplies of food and clothing, and warmth would be quickly menaced. Blot out the radio, and the telegraph, and the telephone, and modern methods of business would be ruinously disorganized. One need not further pursue the parable, although only the most conspicuous examples have been cited of our dependence upon engineering skill, and, if hygiene and physical health were further brought into the picture, the devastating consequences of the removal of these innumerable scientific devices which make for our comfort and protection would be instantly and completely in evidence.

It would be impossible to analyze from the total complex of human effects produced by technical causes just those for which any one man like George Westinghouse is responsible. Indeed, it is only less impossible to determine just what changes in our patterns of human behavior are attributable to particular technological developments to which many individuals may have contributed. What we can in some degree do is roughly to evaluate the consequences for civilization and for human welfare and happiness of definite types of engineering achievement. Even this is a precarious undertaking.

TRANSPORTATION AND NATIONAL DEVELOPMENT

In our own country, with its vast area and its divergent natural resources, even the most phlegmatic imagination can picture something of what rapid transportation of freight and passengers has accomplished. Together with other similar agencies, it has gone far to fuse into one economic nation a great group of territorial empires. California and Florida, 3000 miles apart, furnish New York and Duluth with fresh fruits throughout the winter and fresh vegetables for almost any season. This achievement is partly due to skillful processes of refrigeration, but largely to fast freight, now carried by rail and perhaps presently to be carried still more quickly by air. Without the engineer, none of these things could have been done and we should still be living like our grandfathers chiefly upon the foodstuffs supplied by the immediate countryside about our homes. What is true of fruits and vegetables is equally true of grains, and meats, and fish. Climate and seasons and limitations of soil have been practically wiped out by putting at human disposal the products of the most remote lands. Apart from the sheer aesthetic satisfactions of such a situation for its beneficiaries, there can be no doubt that diet can thus be made more varied and nutritionally more adequate—certainly far more palatable.

Improved travel and transportation have also revolutionized business methods. The buyer now visits the great centers two or three times a year, whether in his own country or abroad, and determines what to stock and arranges the prices which he is willing to pay, where a generation ago the local middleman and merchant took what the distant manufacturer offered and the local trade had only the choice to take it or leave it. The result of this fundamental alteration in commercial methods, deriving distinctly from improved and cheapened travel, has been not only a vast stimulation of retail business of every kind, but also a tendency to put every part of the world in touch with the developments going on elsewhere. Whether the general uniformizing of tastes and fashions, thus occasioned, is an unmitigated blessing may well be questioned, but of the actual economic and social effects there can be no doubt.

Tourist travel has, as is well understood, become one of the highly important elements in international relations, especially those of a financial character. So far as the individual is concerned, modern transportation has thus opened up an entirely new world of experience. What use the citizen makes of this opportunity depends, of course, upon his intelligence, his imagination, and his general social background. The gross effect of these modern devices for quick and inexpensive movement by land, and water, and air is that the world has shrunk to a mere fraction of the dimensions which our colonial ancestors knew. To go from New York to Bombay is far less of a venture and vastly less time-consuming than in 1776 was the journey from New York to Lake Superior.

ELECTRIC POWER

Few contributions of the engineer have exercised more far-reaching consequences than the cheap long-distance transportation of power. Industrial plants have sprung up far from water powers and in places where land values were low and the conditions of life for employees simple, inexpensive, and wholesome. Costly power-producing plants have been scrapped and in their places power transmission from a distance has been installed. Such transmission of electricity to run our railroads, trolleys, and subways has long been a familiar element in our life.

The farmer has similarly had cheap power brought to him to run the various pieces of machinery which the modern farm requires. Needless to say, he has long had electric light.

The changes which have been mostly directly due to easy and rapid transport are paralleled in other aspects of life affected by other engineering achievements. It is thus a commonplace of comment that in earlier days our textiles were made in or near the home. Now we may at any time find ourselves wearing materials fabricated a thousand miles or more away at an amazingly low price and these are offered to us in a bewildering array of fashions.

Our great grandfathers read by candle light, or by poor lamps. We press a button and the whole house is flooded with light. In winter they sat about defective stoves, or huddled over open fires which, with all their aesthetic charm, are poor means for heating a house in our severe climate. We start the thermostatically controlled furnace in the autumn and forget it until spring once more ushers in the summer, and, while no such devices are foolproof and none can be counted on to work wholly without occasional interruption, they are extremely effective in preserving appropriate temperatures and in ridding the housekeeper of the endless routine of replenishing fires and caring for ashes. Westinghouse first solved this problem for the denizens of favored regions by devising means for the distribution of natural gas. Coupled with modern methods of heating may well be mentioned ventilating systems and air cooling for all of which we are beholden to the engineer. And for most of these as well as for our refrigerators and for a score of other appliances in the modern home we are dependent upon electric power which comes to us by the system which Westinghouse so successfully sponsored.

ENGINEERING ACHIEVEMENT AND ECONOMIC ADJUSTMENT

I have said nothing of the crucial achievements connected with the control of water supplies, the disposition of sewage, and the surveillance of disease-free milk and foods, all of which are blessings that we owe in part to engineers and in part to our medical scientists. The dividing line between the scientist, in whatever field he may be proficient, and the engineer who makes his discoveries available to men by practical devices, is always difficult to draw. For our present purposes, it is not essential that we should make this effort. Suffice it to say that, together with the dramatic changes which we have touched upon in the form and manner of modern life, due to the contributions of engineers, these which are related directly to health are of the very first consequence. Let me repeat that it is quite impossible to sort out just those changes in our culture and civilization for which Mr. Westinghouse is most immediately responsible; but it is an entirely safe assertion that in transportation broadly conceived lay his greatest contribution and that the social and economic changes deriving most immediately thence are those for which we are chiefly indebted to him—and a tremendous debt it is.

A few years ago our newspapers and periodicals were much concerned with an intellectual fad calling itself technocracy. This has largely passed out of the area of acute interest, but it did raise certain enduring questions which cannot, and must not, be forgotten. For one of the conspicuous facts about mechanical inventions is that when they affect industrial activities giving employment to large groups of people, they may occasion sudden large-scale dislocations of labor with periods of unemployment which compel society to step in and in one form or another assist in the economic readjustment. This is nothing new in the world. It has been true ever since the beginning of the great industrial movement in Britain in the early part of the last century. It is important in the present context of which I am speaking simply because it is one of the most striking demonstrations of the effect which engineering progress may have upon the social and economic life of a nation. The time has long passed when we can look upon these developments as simply interesting eccentricities exercising purely local effects. They constitute part and parcel of the very fiber of our contemporary life and when we are willing to accept the benefits which they bring to us in the form of cheaper and better food and raiment and such like blessings, we must be willing to see to it that by whatever precautions our neighbors are not compelled to pay in poverty and suffering for the advantages which we enjoy. Nor can we wish off on the individual industrialist, or manufacturer, the entire responsibility for this situation. So long as we issue patents and protect the holders and permit them to manufacture their labor-saving devices and the goods flow from them, we are morally bound to see to it that all parts of the community are protected, as well as the patentee, from any ill-advised consequences which may flow from his industry and intelligence. The fact that in the long run labor-saving devices apparently lead to the discovery and perfection of new modes of human activity, which ultimately engage the displaced labor population, does not exonerate us from a due regard to the consequences during the periods of transition when fresh equilibrium is being established.

Practically all of the changes which during the last century have determined the external complexion of civilization and much of its internal quality rest on just such ingenious and carefully matured devices as George Westinghouse gave his life to perfecting, and the great enterprises of industry and commerce and transportation constantly testify to the profound effect it has all had upon the daily experience of millions of people. Moreover, there can be no question that through these agencies the world has been brought into a more closely knit relationship of mutual dependence and that in many respects the life of the average person has been made safer, easier, and more enjoyable. Nevertheless, there are those who insist upon raising the question whether in its fundamental essentials human life has been really enriched by all these changes, for which we are indebted to the technological developments of the last century or two. Such persons insist on asking whether we are really happier for it all, whether we are really more civilized. Is our culture richer, more fruitful, more potent for future progress, than it was before these things occurred? Is human life better safeguarded? Is poverty less a menace, are crime and disease less sinister in their consequences? To some of these questions an unequivocal affirmative can surely be given.

Human health is certainly better protected, and disease, particularly epidemic disease, is on the way to be in large measure scotched. But, if one be committed to an austere and stoic philosophy of life, one may with some show of cogency, defend the simpler, more independent and more rigorous manner of living, in which luxury was relatively infrequent and comfort far less familiar than today. Men who entertain that view are apt to assert that the essential moral quality of human character has been weakened and that not a few of the by-products of scientific and technological discovery have been vulgarizing to taste and disintegrating to morals. They raise the question whether mankind has as yet achieved a mentality and a moral fiber to make all these great contributions to progress really significant and valuable. They are apt to urge that such changes have come too fast and that we really now need a prolonged moratorium in the field of scientific and engineering invention in order that we may socially and spiritually catch up to the physical factors of the world in which we live.

HUMAN WELFARE VS. SHEER DESTRUCTION

Questions of this kind are in a sense perhaps romantic, for after all the changes are here and society is in process of adjusting itself to them. Nevertheless, it is a fact that the same scientific and engineering skill which, turned in one direction, produces human happiness and welfare may, with little or no change except that of the moral purpose of the user, be converted into means for sheer destruction. The familiar illustration of all this is the direction of the skill of the chemist away from useful employments which promote health and happiness to the production of poison gases by which millions of innocent people may in an instant be put to death. This extreme illustration can be easily capped by dozens of others in which direct physical injury to human life is decreasingly in evidence, but where the disintegrating effects upon morals may be convincingly exhibited.

All this line of consideration reduces to the familiar ethical truism that no fact taken of and by itself is necessarily either good or evil, but inevitably depends upon the purpose to which it is put and the results which emanate from its use. In this sense, I think it must be admitted that the great task of our day and generation lies more in the field of morals and even religion, if you will, than in the field of engineering and economics narrowly conceived. As I read the life of George Westinghouse, I carry away the conviction that he would himself be increasingly disposed to take this view had his life rounded out the century. Certainly his own career is a vivid object lesson in the advantages of simple living, high aims, and hard work, and it is impossible to believe that he would have felt anything but regret could it be shown that the industrial age to which he gave such brilliant leadership throughout his life was contributing to soften the fiber of the race, or to introduce into it elements of moral disintegration. Most of us believe that this is quite untrue and that the great engineering victories of men like Westinghouse constitute a blazing challenge to us to build a social order which is able to incorporate in itself all these blessings, while safeguarding the finest values that inhere in the human spirit.

COURT OF HONOR—WORLD'S FAIR, 1893

(The lighting of the World's Fair at Chicago was one of the dramatic successes of Mr. Westinghouse's career.)

Progress in RAILROAD MECHANICAL ENGINEERING *in* 1936

Developments Characterized by Higher Speeds

THROUGHOUT the world, railroad developments are characterized by speeds. This development is still gaining momentum. The United States has rapidly achieved leadership after lagging behind for several years. According to a statement by J. J. Pelley, president of the Association of American Railroads, more than 400 trains, covering in excess of 19,000 miles, are now operated at scheduled speeds of 60 mph or better as compared with 30 trains operating over only 1100 miles six years ago.

Many train schedules do not seem remarkable at first but are when the character of the line is considered. In France, the Paris-Lyon-Méditerranée runs its Riviera express at 59 mph for 318 miles over a curved, difficult route through hilly country, where the 800-hp, 62-ton Bugatti rail car reaches only 16 per cent higher speed. In Austria, through trains over the electrified mountain lines are scheduled at almost the maximum speed that the curvature will safely permit; thus, on a 2.3 per cent grade with 5 to 7-deg curves between Innsbruck and Salzburg, trains ascend at 40 to 43 mph and descend at a constant speed of 43. Power requirements are high, exceeding 6 and 7 hp per ton of gross weight, including the locomotive. In a recent test to determine whether a 14-car passenger train weighing 750 tons could be handled by the new German 1-D-1 (axle arrangement) electric locomotive of class E18, over the mountainous division from Munich to Stuttgart, 149 miles, at the present timing of the Vienna-Paris express, namely 53 mph, performances of 5300 hp with a maximum of 6100 were found to be required of the 120-ton locomotive. Even Switzerland, where the opportunity for high-speed services, is relatively small, is building three-car electric trains capable of 93 mph.

The development of freight services is likewise remarkable. While in this country freight-train speeds of 45 to 60 mph over long distances have been common for several years where suitable motive power is available and overnight delivery between points 400 to 500 miles apart is established in many cases, Europe has been a land of slow freight-train speeds until recently. However, an international agreement makes air brakes compulsory on freight cars for international service after 1940, as a prerequisite for a general increase in freight-train speeds. The great problem now is the modernization of freight motive power. Special fast freight trains, already in service in Europe, are hauled by passenger locomotives. The German *Fruit Express* which brings fruit from South Germany to the North German provinces in an overnight run of 450 miles, already reaches an average speed of 56 mph.

AMERICAN AND CANADIAN LOCOMOTIVE DESIGN

The remarkable success of certain high-speed locomotive developments of 1935 has been maintained in the current year. An outstanding example, the *Hiawatha* of the Chicago, Milwaukee, St. Paul and Pacific, carried nearly a quarter of a million passengers the first year of its operation. The flexibility of the steam locomotive, originally designed for hauling six cars, made possible an increase of the load to eight cars without difficulty, so that a third locomotive, ordered in February, 1936, could be made identical with the two original engines.

Apart from the third *Hiawatha* engine, the oft-predicted demand for lighter steam locomotives has found expression only in Canada. Starting in July, 1936, the Canadian Pacific received five 4-4-4 semistreamlined high-speed locomotives with 80-in. drivers to haul new lightweight steel cars. This engine is lighter than the *Hiawatha*, having an adhesive weight of 121,000 lb and a total weight of 263,000 lb. A four-wheel trailing truck is used to reduce rail stresses. The tractive power is 26,500 lb, 14 per cent less than that of the *Hiawatha;* the locomotives burn coal on a grate area of 55.6 sq ft, and have an ample boiler evaporative surface of 2833 sq ft. The steam pressure is 300 lb per sq in. In the United States, 115 steam locomotives were ordered in the first three quarters of 1936 compared with no electrics and about 40 Diesel-powered units including those for streamlined lightweight trains but chiefly for switching service. The steam locomotives are mostly of the heaviest types, from the 4-6-4 up.

The 4-8-4 passenger locomotives of the Chesapeake and Ohio, five of which were delivered in 1935 after last year's report had been presented, are running in the Alleghenies and the Blue Ridge Mountains over 1.52 per cent grades and are among the most powerful of their wheel arrangement, having an estimated indicated capacity of 5000 hp and a weight of 477,000 lb.

The year also brought the revival of the six-wheel switch engine which, generally speaking, seemed to have little chance in the face of Diesel competition and which had not been built for several years past. In 1936, however, five, with tender booster, have been delivered to the Union Railroad, three to the Inland Steel Co., and one to the Lehigh and New England. One more was ordered in August by the Monessen Southwestern.

A novel wheel arrangement, 0-10-2, was chosen for these locomotives for the Union Railroad. They are probably the most powerful in their kind of service, having a weight of 404,000 lb exclusive of tender, boiler pressure of 260 lb, 28 × 32-in. cylinders, 61-in. wheels, and grate area of 85.2 sq ft.

The outstanding steam experiment now under way in this country is the construction for the Union Pacific Railroad of a 5000-hp, two-unit turboelectric locomotive, to be delivered early in 1937. This effort is timely, since the only previous attempts to introduce the drive were made in England by the North British Locomotive Co., Glasgow, in 1910 and 1923, when both the turbine for locomotive service and particularly the electric transmission were in an inferior state of development. This prospective locomotive, however, tops the list of turbine locomotives thus far built, data on which are to be found in Table 1.

The future of the steam locomotive, broadly speaking, depends largely on the development of its availability. The Burlington has found an availability of 69 per cent for a modern

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Condensed from a report prepared by Railroad Division, Committee RR6, Survey, A. Giesl-Gieslingen, chairman, and presented at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, N. Y., Nov. 30 to Dec. 4, 1936. Copies of the complete report can be obtained upon application to the Society.

PENNSYLVANIA STREAMLINED K4S PACIFIC TYPE LOCOMOTIVE

Hudson type locomotive in $2^1/_2$ years' service with a daily assignment of 510 miles. This compares with 9 per cent availability for the original *Zephyr* in 16 months on an assignment of 500 miles. Although the latter percentage will probably be lower as general repairs become necessary, the chief effort of steam-locomotive designers must be directed toward bettering availability, so that the lower first cost will manifest itself more fully. Lower repair cost should then be obtained automatically. As a prerequisite, analysis of the factors which at present impair the steam locomotive's availability is needed.

Steam-locomotive streamlining continues on a limited scale; and, with due regard to wind-tunnel tests and reducing resistance and preventing objectionable exhaust trailing, it is also largely regarded as a matter of style to attract public attention. Outstanding designs of the current year are: The streamlined K4S Pacific type of the Pennsylvania Railroad and that of the *Mercury*, the new streamlined train of the New York Central, between Cleveland and Detroit, which is likewise a converted standard Pacific type.

Significant of changing requirements is the transformation of the Burlington class M-4, 2-10-4 type freight locomotives with 64-in. drivers, built in 1929, to make them suitable for higher speeds. They were fitted with new box-shaped driving wheels, cross-balanced main drivers, and with roller bearings on all axles. Cylinders of smaller diameter, 28 × 32 in., reduced the tractive force from 90,000 to 83,500 lb and rods were lightened. Thus, these engines are now suitable for heavy fast-freight service at 55 mph instead of the 35 mph attained before transformation.

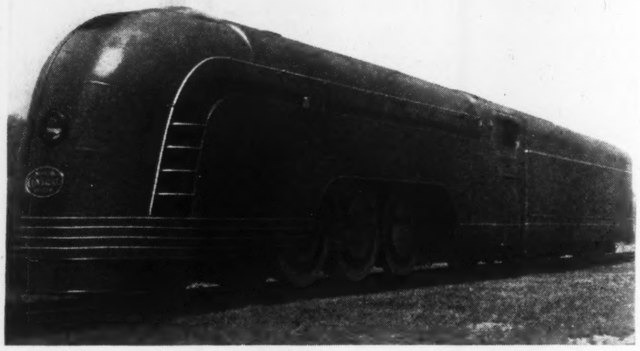
MORE STEAM LOCOMOTIVES BUILT ABROAD

Locomotive building was relatively greater in many foreign countries than in the United States, although it also was, with few exceptions, confined chiefly to conventional types. In Great Britain, about 500 conventional locomotives will have been turned out in 1936. This corresponds to a replacement quota of $2^1/_2$ per cent, but the fact that rebuilding is widely practiced in British railroad shops must be remembered. On the Continent, replacement quotas were smaller, approximately 1 per cent, because of economic necessity and in anticipation of developments and experiences in high-speed service.

The most powerful Pacific type locomotive in Europe is the Belgian class 1, a four-cylinder simple engine which is also the fastest with a permissible service speed of 87 mph using 78-in. drivers. The first 15 engines were built in 1935 and 20 more were ordered this year. The axle load is 53,000 lb, likewise the maximum figure for Europe; the adhesive weight is 159,000 lb; the engine weight, 278,000 lb; and that of the tender, loaded, 184,000 lb. The 16.5 × 28.4-in. cylinders are equivalent to two cylinders 23.4 in. in diameter. The tractive power at 85 per cent and a boiler pressure of 256 lb is 43,300 lb, resulting in a factor of adhesion of 3.68. The grate area is 53 sq ft and the evaporative surface on the fire side, 2530 sq ft. According to practice in the United States, the boiler does not appear to be ample, but the coal is of high grade. These engines haul, for example, the Ostend-Vienna-Orient Express between Brussels and Ostend, 76 miles, in 67 min with one stop.

In France, the Nord Railway exhibits a rare spirit of impartial judgment in having under construction 28 Pacific type locomotives of a design that was developed on the Paris-Orleans road and found to be superior to its own Pacific type engines. Essentially the design was created by rebuilding older engines as described in *Railway Mechanical Engineer* for November, 1931, p. 527. It features oscillating-cam poppet valves, ample, scientifically designed steam passages, and a double stack.

The French Nord Railway's own design of fast Mikado type suburban tank locomotives with Cossart cam-operated piston valves has been successful. Seventy-two engines are now operating and, with strictly modern cars, are performing a most impressive suburban service around Paris. Eight-car trains are being pulled in one direction and pushed in the other to expedite reversing at terminals; this is accomplished by having the rear car equipped with a driver's cab and electric remote control of the steam locomotive, in which this road has pioneered.



N. Y. CENTRAL STREAMLINED K5 PACIFIC TYPE LOCOMOTIVE
Mercury

In Germany, two new standard locomotives are in preparation. One, a 4-8-4 for 87 mph with 79-in. drivers, will be the first of this wheel arrangement in Europe. Its construction is necessary because the present standard passenger engine, the class 01 Pacific type of 2500 hp and 35,600 lb tractive force, is often unable to maintain the schedule with through trains if conditions are but slightly adverse. A new Santa Fe type for 56 mph with 63-in. drivers is intended to satisfy the requirements of heavy, fast freight service for which the existing decapods are likewise inadequate. Both designs will have three cylinders and single expansion, with 285 lb pressure.

The number of specific high-speed engines has not increased in Germany in the current year. Two 4-6-4 three-cylinder streamliners class 05 are now in service. One of these is serving test purposes while the other is making a nonstop run between Berlin and Hamburg, 178.2 miles, on a 74.3-mph schedule. One of these locomotives has attained a speed of 126 mph. In addition one 4-6-4 two-cylinder streamlined tank engine class 61 is now making two round trips daily between Berlin and Dresden with a specially built four-car light-weight train, and covers the 109.5 miles at 69.2 mph. Both types are designed for about 110 mph, with due allowance for higher speeds

TABLE 1 TURBINE LOCOMOTIVES BUILT ABROAD

Year built	Design	Type	Wheel arrangement[a]	Hp	Builder	Railroad	Remarks
1910	Reid-Ramsey	Turboelectric	....	..	North British Locomotive Co.	....	First attempt
1923	Ramsey	Turboelectric	1C + C1	1000	North British Locomotive Co.	....	Scrapped
1921	Ljungstrom	Condensing, geared	5 + C1	1800	....	Swedish State	A second improved engine built
1923	Ljungstrom	Condensing, geared	....	1500	....	Argentine State	
1926	Ljungstrom	Condensing, geared	....	2000	Beyer, Peacock	British L.M.S.	....
1927	Reid-McLeod	Condensing, geared	2B + B2	1000	North British Locomotive Co.	....	....
1924	Zoelly	Condensing, geared	2C	...	Winterthur	....	....
1924	Zoelly-Krupp	Condensing, geared	2C1	2000	Krupp	German State	In service
1926	Zoelly	Condensing, geared	2C1	2500	Maffei	German State	In service
1924	Zoelly	Geared condensing, tender	....	...	Henschel	German State	Not a commercial success
1931	Zoelly	Geared condensing, tender	....	...	Henschel	Argentine State	....
1933	Zoelly	Geared condensing, tender	....	...	Henschel	U.S.S.R. State	....
1932	Ljungstrom	Exhaust, geared	1D	1200	....	Swedish State	....
1925	Ljungstrom	Exhaust, geared	2C1	2500	....	British L.M.S.	....

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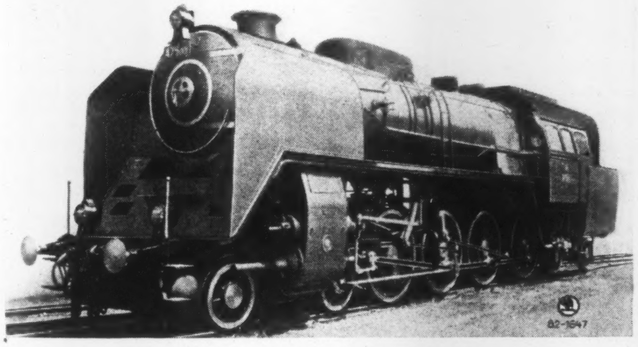
[a] Figures indicate number of axles; letters are used for driving axles.

occasionally attained, but they are hardly reaching more than 90 mph in the services in which they are operating, as they are limited by braking distances.

The former type of engine closely approximates the *Hiawatha* in tractive force and capacity as well as weight, but on account of the lower permissible axle load of 42,000 lb has one more driving and one more carrying axle. In test runs, it generally developed 2900 to 3000 ihp at high speeds but could be driven to 3400 hp at 106 to 120 mph. The class 05 is thus, at present, the most powerful steam locomotive in Germany.

The class 61 tank locomotive is interesting for its compactness. Built to haul a four-car train weighing 137 tons empty and seating 196 passengers, the engine is somewhat overdimensioned and is able to handle a much higher load, having about 60 per cent of the *Hiawatha's* indicated capacity. The weight in service order, but without coal and water, is 233,000 lb; the water supply of 4500 gal is sufficient for 150 to 200 miles and the coal supply for double that distance. This engine with its train is entering in direct competition with Diesel lightweight equipment. The tractive power is 25,800 lb.



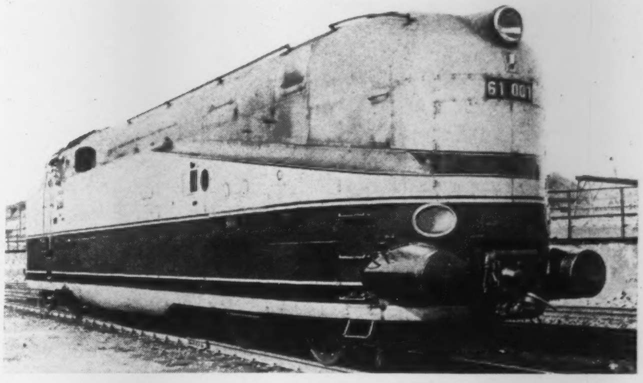
BELGIAN NATIONAL RAILWAYS CLASS 1, PACIFIC TYPE LOCOMOTIVE

Another German tank-engine development of 1935 has given good results and led to an order for another slightly more powerful engine. It is the 2-4-2 streamliner of the Lubeck-Buchener railroad, a German private line, the traffic of which is of a suburban character and on which, following the French example, the engine is either pulling or pushing, at speeds up to 75 mph, an articulated two-car train of special double-deck construction, seating 300. When pushing, the locomotive throttle is electrically controlled from the end of the train. The new engine will be able to handle two such articulated units.

On the London and Northeastern of Great Britain, a third engine of Sir Nigel Gresley's *Cock o' the North* class (2-8-2 passenger) has been added, with streamlining approximately following the *Silver Link* (Pacific type engine of 1935) which has been found fully effective in preventing smoke trailing. Three more such locomotives are under construction. Further, a new three-cylinder Prairie type, the *Green Arrow* class, has been created, of which 32 are now being built. Both classes of locomotives are notable for the use of two-wheel trucks at high speeds, resulting in avoidance of excess length and dead weight, and, thus, in an extraordinarily favorable ratio of adhesive to total engine weight, namely 73½ and 70½ per cent, respectively.

Interest in turbine locomotives centers around the record of last year's experimental noncondensing Pacific type engine of the London, Midland and Scottish Railway. Up to October, 1936, this locomotive had given 12 months of successful service, mostly between Euston Station, London, and Liverpool. However, according to the personal statement of its originator, Mr. Stanier, the overall economy is still questionable and, owing to the characteristics of the turbine direct drive, "one or two stops may easily destroy all economies obtained while running."

Two German turbine locomotives, now both more than ten years old, are in operation, but no extension of such types is considered. The Krupp locomotive has just been remodeled by the installation of a reverse turbine in high gear, which is



GERMAN STATE RAILWAYS 4-6-4 TWO-CYLINDER HIGH-SPEED TANK LOCOMOTIVE also used for starting the locomotive forward to reduce starting steam consumption.

Two outstanding steam-locomotive developments are scheduled to appear in 1937:

(1) A Velox boiler, with combustion under pressure, is being applied to a 4-6-0 passenger engine of the French Paris-Lyon-Méditerranée Railroad, by the Cie Electro-Mécanique at Le Bourget. The engine is a standard four-cylinder compound for 75 mph, as built for almost 30 years, for a steam pressure of 228 lb and, thus, only the boiler will differ from standard, to permit correct comparison. A boiler efficiency of 90 per cent has been guaranteed. The Velox system of steam generation has been developed by Brown, Boveri and Company, Switzerland.

(2) A 4-6-4 high-pressure locomotive, Winterthur type, was ordered in July, 1936, from the Société Alsacienne by the French Nord Railway. This locomotive will work at 850 lb and will be particularly notable for its independent axle drive and its two small high-speed three-cylinder steam "motors" with 5.9 × 10-in. cylinders working on each of the three driving axles. The design speed is 81 mph and the diameter of the drivers, 61 in. The performance should be over 2500 hp and the total weight about 130 tons.

Thus, the high-pressure locomotive is again being revived. Independent axle drive by steam motors is also capable of development in connection with conventional boilers. In a recent publication, the Henschel Works of Germany propose it as an advantageous solution for high-speed service. The problem appears to be worthy of investigation, particularly now that the L.M.S. turbine locomotive has demonstrated the practicability of torque transmission directly to an axle without the jackshaft and rod drive formerly used, thus following established practice on electric locomotives. Independent axle drive opens some interesting prospects, such as cutting out driving units at high speed, being so to speak a development of the booster principle; standardization of steam engines; possibility of quick change of driving units over the drop pit; and use of outside frames with a broad spring base and soft spring suspension.

BOILER AND ACCESSORIES

In this country, the Baltimore and Ohio continued installations of the Emerson type water-tube firebox for a pressure of 359 lb.

The conventional stayed firebox is used for 300 lb pressure on several locomotives of 1936 in this country and in Canada, but pressures of approximately 260 lb are prevalent. On the Continent where higher pressures are used than elsewhere abroad, the highest pressure for new designs with stayed boxes is 285 lb. This applies also to Germany, where three years of experience are available with conventional boilers for 356 lb pressure on Pacific and decapod type compound engines. Speaking of limits of pressure, "satisfactory" with regard to stayed fireboxes is a vague term. The firebox is still a troublesome part. In Europe, the question of steel versus copper boxes is undecided even after decades of comparative testing. The Paris-Orleans Railway, for instance, has favored steel for several years, yet the French Nord Railway, which bought the P. O. Pacific type locomotives mentioned previously, complains of trouble with the steel fireboxes of these engines that are otherwise so satisfactory. Recently, the American practice of welding firebox plates and tubes is spreading in Europe with both copper and steel boxes, and in the latter, staybolts are being welded on the fire side.

In Germany, where pulverized-fuel firing has long been experimented with for using low-grade bituminous coal, six consolidation and four decapod freight locomotives are now in service. The third class 05 streamliner, under construction with a modified boiler for pulverized coal, will have A.E.G. burners, and should be placed in service early in 1937. Unlike the other engines, it will have a combustion chamber. A steel firebox will be used because of the sulphur in the fuel. The A.E.G. designs are now also exploited by the STUG, the company formed for studying pulverized-fuel firing.

An interesting development in boiler feeding has been accepted as standard on the Austrian Federal Railways and is now used on 70 locomotives, including Rumanian and Indian. Seeking to reduce the considerable steam consumption of conventional feedwater pumps, the Heinl two-stage open-type preheater has been developed, wherein the entire heat in the pump exhaust is reclaimed by admitting it into the feedwater circuit under moderate pressure. A compact design, simple in detail as well as in operation, was finally produced. An interesting feature is that a high steam consumption of the pumping engine does not affect the total heat consumption of the feedwater pump. The pumping engine may have leaky steam-piston rings, and yet this condition will merely reflect upon the pumping capacity and not upon the fuel consumption. The oil separators are also noteworthy. Small size and high efficiency are attained by imparting particularly rapid rotation to the steam flow in the throat of a venturi-shaped pipe.

In smokebox draft appliances, no new developments in principle have come into use, but the double stack is steadily gaining ground and has become standard in the countries of its origin, Belgium and France. This means that the value of liberal outlet areas for the smokebox gases is being recognized. Such large outlet areas should be obtainable in a simpler way; for instance, by imparting greater conicity to the steam jet to fill a wide stack outlet, as has been done in the Le Maitre exhaust now gaining recognition in France and, much earlier, in the Austrian class 214 locomotive. Incidentally, Le Maitre is now advocating the use of a stack of oblong cross section, as a means of realizing any desired outlet area. This can be envisaged as a development of the Oatley stack, conceived in this country more than 16 years ago, at a time when the importance of efficient draft appliances was not yet generally recognized. Improvements in the conventional Master Mechanics' front end were reported upon before the A.A.R. last summer.

Smoke-lifting devices have become desirable with increasing speeds and especially where large stack areas are used. The simplest device for standard locomotives is still the old German side-plate arrangement. At high speed, such plates induce a power loss which has been found to be on the order of 100 hp at 100 mph. This would be objectionable, but streamlining reduces the size of the required side plates, or they can even be dispensed with as claimed for the British form of streamlining. The Pennsylvania has developed another smoke lifter for streamlined engines. The matter is still one of trial and error. A new method for determining en route, the effect of aerodynamic devices upon the resistance of a locomotive has been developed by the French Est Railroad.

STEAM-ENGINE DRIVING AND RUNNING GEAR

Progress in application of poppet valves has been confined to roads accustomed to their use, primarily in Austria and France. Current tests in Germany are made on Pacific type locomotive No. 03.175. The case of rotating versus oscillating cams is likewise undecided. The French Nord Railway uses light-weight piston valves, four per cylinder operated by rotating cams on its 72 fast Mikados for suburban service, class 4200, but poppet valves operated by oscillating cams on the new Pacifics.

The application of roller bearings to all axles, as an important step toward higher availability, is making rapid progress in this country. The resultant rigidity of the axle assembly calls for refinements in shop methods. Abroad, activity this year has been confined to truck applications, but early in October, 1936, a German class 01 standard Pacific type locomotive was experimentally equipped with roller-bearing rods. The Krupp Works delivered a roller-bearing rod set for a small 0-4-0 locomotive in India.

The Austrian Federal Railways adopted a method of axle pressure lubrication that was developed by Friedmann, according to which the adhesive forces between the oil and a disk rotating with the axle are utilized. The disk runs through the oil well and is surrounded by an eccentric ring so that the minimum space is left between the disk and the ring at the point of oil delivery, where the oil pressure reaches its maximum value. Unlike other mechanical lubricating systems, this method appears to deliver a strong stream of oil without agitating the liquid. As many as 4000 applications to locomotives and cars are reported to be in service to date in Europe.

Aluminum main- and side-rod installations are making some progress in this country on freight locomotives. Comparison with alloy-steel rods of scientific design appears to be lacking to date. As to the latter, a molybdenum content is now regarded abroad as an important factor in reducing temper brittleness of nickel and nickel-chromium alloys.

The Commonwealth cast-steel frame with integral cylinders is used on many current locomotives. The built-up frame, on the other hand, has been improved in homogeneity and strength by cutting the side-frame members from a rolled-steel slab. This method, which has been standard in Germany for decades, has recently been adopted by the Lima Locomotive Works.

The locomotive brake system has been refined, particularly in Germany, to attain a stopping distance of 3300 ft from a speed of over 90 mph. With a tight coupling of the cars, no need of having the train stretched during the braking period exists, and the locomotive can fully participate in the braking action. As in high-speed Diesel practice in the United States, four 12-in. brake shoes per wheel are used on all modern Pacifics and on the high-speed locomotives of the German State Railways. For the latter, the maximum braking ratio is 180 per cent on leading-truck wheels, and 75 to 80 per cent on second-truck wheels. A speed-dependent pressure regulator has been installed for the first time on the class 05 high-speed engine. Tire life is an active problem in this case, and tests with harder tires are in preparation.

The running qualities of the locomotive as a vehicle are naturally receiving attention. Recently reported tests made in this country on the Pennsylvania showed that the 2-C-2 (axles) type electric locomotives, class P5, built a few years ago, unduly stressed the track at high speed. Investigation showed that a certain degree of lateral unevenness of the track was required to induce hard lateral blows and that these blows could be greatly reduced by forcibly restraining the locomotives from nosing by high initial centering forces at the end trucks. A locomotive of the articulated 2-C plus C-2 axle arrangement, designated as class GG1, gave the best running qualities. Abroad, the Paris-Lyon-Méditerranée is making analogous tests with steam locomotives, and, in Germany, much theoretical work is in progress.

DIESEL MOTIVE POWER IN THE UNITED STATES

On the large Diesel high-speed lightweight trains placed in service during the year by the Union Pacific and the Burlington, the power cars serve no other purpose and are, therefore, more strictly speaking, locomotives. Their equipment does not differ from that of Diesel "motor cars," and, therefore, both are discussed under the same heading. Motorization, in general, is advancing faster in many places than is generally known. For example, the Czechoslovakian State Railways expect to average during the current year, 800,000 motor car-miles per month. There, and in other countries where distances are small, motorization has, of course, found a particularly suitable basis.

In March, 1936, the Illinois Central placed a 171-ton, 1800-hp, Diesel-electric transfer locomotive, equipped with two Ingersoll-Rand six-cylinder four-cycle engines and General Electric transmission, in service. The Diesel engines of this locomotive, No. 9200, have vertical single-acting cylinders of $14^3/_4$ in. bore and 16 in. stroke, and deliver their rated output at 550 rpm. The power plants are mounted on a welded-steel underframe, and the draft gears are directly attached on the cast-steel truck frames. The six motors are geared to permit the maximum locomotive speed of 60 mph, corresponding to 2140 motor rpm.

The second transfer locomotive of the Illinois Central, No. 9201, is of similar mechanical construction and also has General Electric transmission, but it is powered by a single 2000-hp Busch-Sulzer Diesel engine, probably the largest thus far completed for locomotive service. The total weight is 173 tons. Compared with the former locomotive, the problem in designing the fabricated underframe, which in this case has to carry the 50-ton engine generator set located midway between truck centers, was greater. The two-cycle Diesel engine has 10 single-acting cylinders in V-arrangement, of 14-in. bore and 16-in. stroke, working at the maximum of 550 rpm. The motors are also geared for a service speed of 60 mph.

A 133-ton, 1600-hp twin-engine Diesel locomotive, carried on two four-wheel trucks, was built for demonstration purposes by Westinghouse early this year. The two four-cycle engines have 12 cylinders each in V-arrangement and operate at 900 rpm. The locomotive is geared for 50 mph maximum.

Several outstanding streamlined Diesel trains went into service in the year. The dates on which the different trains commenced operation and their names are as follows: May 17, the five-unit *Green Diamond* of the Illinois Central, between Chicago and St. Louis; May 15, the 11-unit *City of Los Angeles* (M-10002) of the Union Pacific, between Chicago and Los Angeles; the somewhat modified 11-unit *City of San Francisco* (M-10004) of the same road for the run between Chicago and San Francisco; June 18, the two 12-unit trains *City of Denver* (M-10005 and M-10006); and November 7, the two 12-unit *Denver Zephyrs*, between Chicago and Denver on the Burlington.

The *Green Diamond* consists of five articulated car bodies, one of which is used exclusively for power purposes, while the second is a mail car; the three remaining cars seat 120 passengers and 24 at dining tables. The train is 328 ft 6 in. long overall and weighs 476,800 lb light, or 1450 lb per linear ft. The inside width is 9 ft 1 in. The 1200-hp Electro-Motive Company's engine has 16 cylinders of standard dimensions, 8-in. bore and 10-in. stroke, and runs at 750 rpm. Four driving axles are used. The power portion of the train takes up 162,680 lb or 34 per cent of the total train weight. All car bodies are primarily of riveted Cor-Ten steel construction, and liberal use is made of welding.

All the other mentioned streamlined trains have independent two-unit, power cars. The M-10002 and M-10004 have nine articulated revenue cars, mostly sleepers with a capacity of 170 persons; body construction is of aluminum alloy; and the trucks are of cast steel. The former has a 2100-hp power plant with one 1200- and one 900-hp motor housed in cars also of aluminum construction, and the complete train weighs 475 tons light or 1330 lb per linear ft. The length is 714 ft. The power cars weigh 35 per cent of the total, and the service weight is 28 tons higher. This makes slightly more than 4 hp per ton of service weight. The latter train has a 2400-hp plant in Cor-Ten steel riveted power cars and, therefore, weighs 25 tons or about 5 per cent more. The power plant accounts for 39 per cent of the total. Both trains have the same interior cross section as the *City of Portland* (M-10001) of 1935, with a maximum inside width of 8 ft $11^7/_8$ in. and sloping side walls.

The *City of Denver* trains, however, have been built 9 ft $5^1/_2$ in. wide, or slightly more than standard, to provide the spaciousness desired by the public. The clear height is also ample, 8 ft 1 in., and the side walls are vertical. These trains have 10 revenue units, partly in articulated groups and partly detachable with aluminum-alloy bodies, mostly of riveted construction. The capacity is 182 passengers, chiefly in sleepers, and the accommodations are roomy and luxurious. Including the 2400-hp plant in two-unit Cor-Ten power cars, the trains are 864 ft long and weigh 625 tons empty or 1545 lb per linear ft; the power cars weigh 31.1 per cent of the total. In service order, the weight is 42 tons higher, and the motor output available for propulsion is 3.6 hp per ton.

All these trains have Electro-Motive-General Electric power equipment. The Diesel engines operate at 750 rpm and have 12 or 16 cylinders of the same dimensions as those in the *Green Diamond*. Each train has eight electric propulsion motors and eight driving axles, and all are air-conditioned.

This year, the Burlington, to meet traffic demands, replaced the three-car *Twin Zephyrs*, hitherto operating between Chicago and the Twin Cities, by two seven-car trains of analogous type, seating 200 persons instead of 72.

Recently, the Seaboard Air Line installed a 600-hp mail-baggage power car for similar service. It weighs 186,400 lb and contains a standard Electro-Motive V-type two-cycle Diesel, having eight cylinders of the same dimensions and the same operating speed as the Union Pacific trains.

About three dozen Diesel-electric switching locomotives, mostly of 600 hp and of normal type were ordered in the first three quarters of the year for service in this country.

Diesel trains in the United States have demonstrated high availability, the first four *Zephyr* trains of the Burlington having covered a total of a million miles by the end of April, 1936. The availability of European Diesel trains, when equally new, has been lower and more in the neighborhood of 70 per cent which can be traced to initial mechanical difficulties due to the high rotative engine speed chosen for all European Diesel power plants in the interest of minimum weight; namely, 1350 to 1400 rpm for engines up to 600 hp. These difficulties, well known for instance in connection with the 40 three-car trains of the Netherland State Railways, have been overcome by carefully balanced engine design, eliminating the destructive vibrations.

CONTINUED PROGRESS MADE BY DIESEL POWER ABROAD

In Central Europe, the battle between ultra-lightweight equipment built along automobile lines on the one hand and more conventional designs following established railroad-car construction on the other has been decided in favor of the latter, and cars equipped with 410-hp power plants, weighing about 50 tons in service order, are being built in considerable numbers, particularly for Austria and Germany. They are destined for single or multiple operation and have standard draft gears for attaching trailers.

In France, however, experiments are currently continued with extremely light car designs, although some of the ultra-light car bodies of 1934 are already in poor condition after 60,000 to 100,000 miles of service. One remarkable 400-hp gasoline-driven, rubber-tired Michelin car was delivered to the State Railways this summer. It has a rigid body of high-tensile tubing, 99 ft 4 in. in length, obviously the longest in the world. This car has three eight-wheel trucks of which the one in the center has lateral play and contains the driving axles. Although it seats 96 passengers, the total weight is only 36,000 lb light. Another experimental 500-hp three-unit articulated Michelin train for the same road weighs almost 47,000 lb and seats 106 persons. However, the engines of these and similar cars are of automotive type and rated like automotive engines, but their performance in service is not the equivalent of a railroad-type Diesel engine of the same nominal output. The high rating of these cars is evidently misleading.

France had 464 self-propelled rail cars on May 15, 1936, which cover 63,800 miles per day. The most powerful French Diesel vehicles are the eight 154-ton three-car articulated trains of the French State Railways, of which four were delivered up to August, 1936. They have two 600-hp standard Maybach supercharged engines and electric transmission and are for service between Paris and Liége in Belgium.

Renault single-unit Diesel cars equipped with one 500-hp motor will be put in service this year on both the French State Railways and the Est System, one on each line, and will be notable for mechanical transmission. Hitherto, the mechanical oil-operated clutch transmission with five speed stages, developed by the Winterthur Locomotive Works in Switzerland, has been applied to about 200 French rail cars with up to 300 hp per motor.

In Germany, the two 1200-hp (two 600-hp units) Diesel-hydraulic trains put in service last year are giving full satisfaction as to transmission, and extension of the turbine-hydraulic drive developed by Voith is planned. These trains serve the difficult route from Berlin into the Silesian mountains at Beuthen, 318 miles, and are scheduled over a 205-mile nonstop stretch at 77.5 mph. They are reversible three-unit articulated steel trains with a power plant at each end, having a total length of 198 ft and weighing 236,000 lb when ready for service, or 1190 lb per linear ft. The power installation is thus ample with 10 hp per ton of weight, and 125 mph has been exceeded.

A four-car articulated high-speed train with one 1300-hp Diesel engine is under construction. All German trains running at more than 80 mph are equipped with ample magnetic-rail brakes to be used in emergencies.

With 360 self-propelled rail cars at the end of 1935, the German State Railways possessed fewer units than France but had a larger number of high-powered cars; for example, 126 of the 410-hp size. In 1936, over 160 Diesel cars will be added.

The 40 Netherland three-unit Diesel trains now cover 3460 scheduled service miles per day in short runs. Since most of them run in groups of two coupled together with multiple control, this corresponds to about 6500 single train-miles. Their speed is still limited to 62.3 mph, maximum, because of track conditions.

In Great Britain, several 600-hp Diesel switchers are being ordered by the London, Midland and Scottish, while Diesel rail cars are making considerably less progress there than on the Continent.

One-man operation is provided for in many cases but is seldom found in practice on main lines, partly because of the need of constantly educating new personnel. The German State Railways employ an observer as a matter of principle on their ultra-high-speed trains. These trains are operated with the help of a speed chart indicating what speed the driver should maintain at any point of the road. This is facilitated by the extra-large milestones used on German lines indicating every tenth of a kilometer, 328 ft. In Holland, only one man is in the driver's compartment, and eliminating the machinist, who is still employed to watch the engine room located in the center of the train, is also contemplated. At present, where two trains are coupled together, only one machinist is employed, and he watches the two engine rooms alternately, changing at intermediate stops. On branch lines, one-man operation is widely practiced in various countries.

SELF-PROPELLED CARS OTHER THAN DIESEL

After an interruption of several years, the steam-driven rail-car reappeared in this country in the form of the two-unit Besler train put in service this fall on the New Haven between Bridgeport and Hartford, Conn. The Besler steam plant and power truck have been installed in one remodeled 20-yr-old coach with a trailer, for the purpose of making a low-cost experiment. The power plant is capable of delivering 500 hp at the rail and weighs about 32,700 lb including controls, although the engine alone has a capacity of 1000 hp. It consists of two direct-drive outside, two-cylinder, compound engines. The exhaust is condensed. The oil-burning boiler, which is of the flash type, without water header and with full automatic control, delivers working pressure within 4 min after cold starting, and operates between 400 and 1200 lb per sq in., within which limits the engine water rate is said to be approximately 10 lb per hp-hr. The train is designed for a speed of 70 mph but has reached 82 mph. Due to the use of old coaches, the two-car train weighs 303,600 lb ready for service.

Since 1929, the Milwaukee Railroad has had under development, in conjunction with the Ryan Car Company, a steam-propelled car known as the "Locomotor." At present, one of these, a self-propelled motor car equipped with a steam power plant and mechanical drive, is in daily operation.

The boiler is designed to develop 7000 lb of steam per hour at 1000-lb pressure and 750 F and is entirely automatic in operation. With a vaporizing oil burner using a straw-colored distillate at 38 Bé for fuel, the evaporation rate is 12 lb per lb of fuel.

A storage and separator drum is employed between the major evaporator coil and the superheater coil where the excess moisture in the steam is precipitated and is recirculated through the major evaporator coil by an injector. Engine exhaust is passed through oil separators and then carried to condensers on the roof, the condensate being collected in a hot well and used as boiler feed.

The engine is a four-cylinder, 7 in. diameter × 12 in. stroke, double-acting, vertical, uniflow type, and is capable of developing 600 hp. It is mounted about midway in the car between the center sills with the cylinders above the floor and the crankcase below so that the crankshaft is in direct line with the drive shaft. The steam rate is about 11.8 lb per bhp hr.

The car is driven by the front truck only through hypoid gears on both axles. Both the main shaft and the auxiliary shaft that drives the front wheels are equipped with suitable universal joints to allow for swiveling of the truck and lateral and vertical motion of the wheels. The wheels of the drive truck are 43 in. in diameter and, at 600 rpm of the main engine, the car speed is about 70 mph.

Abroad, the Lubeck-Buchen Railway in Germany reports two years of satisfactory experience with a steam-driven rail car of 350 hp designed according to Doble principles. Encouraged by tests of several steam rail cars in Germany in which Doble and Besler principles were utilized under license, the German State Railways is now considering the building of a high-powered steam-motor train for speeds exceeding 80 mph on the basis of a public competition for suitable designs recently held by the German Coal Syndicate which prescribed the use of coal.

In France, two 2000-hp steam-motor high-speed trains with flash boilers have been ordered to Bugatti designs by the Paris-Lyon-Méditerranée and the State Railways. Details of construction are kept secret to date. The former train is expected to be delivered early in 1937 and is destined to cover the difficult route from Paris to Nice on the French Riviera (676 miles) at a speed in excess of 62 mph, for which performance a fuel-oil rate of 2.4 gal per mile has been guaranteed by the builders.

Considerations of national policy abroad are encouraging the study of other fuels. For instance, the French State Railways demonstrated early this year an experimental wood-gas rail car of 210 hp for 75 passengers.

Twenty stainless-steel electric two-car trains are being built under Budd licenses for the French State Railways. On some European roads, advantage has been taken of the possibility of installing large-horsepower electric cars destined for mountain-line service. For instance, the Austrian Federal Railways developed a rail car designated as class ET 11. This seats 80 passengers, measures 77 ft 4 in. over buffers, weighs 106,000 lb, and has 530 hp at the wheels. A speed of 62.3 mph was reached 50 sec after the start. The Swiss Federal Railways installed motors of 540 hp hourly performance in two lightweight cars, weighing only 74,000 lb and not equipped with couplers.

Gasoline rail cars are now of little importance in the face of Diesel competition. In France, however, the influence of rail-car designers connected with the automotive field, such as Bugatti, and weight requirements of Michelin designs resulted in the ordering of several units up to 300 hp.

After several years of clouded vision as a result of the world-wide depression, the public is waking to the need of modern railroad systems. In a paper read before an international congress for traffic problems at Vienna on June 16, 1936, the director of the Austrian governmental agency for the development of tourist traffic predicted that the next few decades will bring a gigantic rise in intercity and international travel, and that this mass travel—at low fares—of the near future will have to be carried primarily by the railroads as the only agency capable of handling it. He added that the railroads must be assisted in passing through the present transition period, so that they will be able to fill the coming needs of nations. These statements, based upon intense study, come from a neutral source, interested only in traffic problems as such. He also stated that increasing the commercial speed to liberally conceived economic limits is a necessity. According to investigations by the German State Railways, the increase in the speed level by 11 per cent between 1932 and 1935 resulted in economies of 9 million dollars due to the more intensive use of equipment and personnel, in spite of rising repair and traction costs. Thus, improvement in the alignment of railroads may well be justified in many cases where curves at present impair speedy operation. This has already been practiced in the United States and is now being done or contemplated elsewhere. Italy has been particularly active in this respect and is now building an almost straight short cut of 60 miles on the Genoa-Venice line.

As to new construction, apart from extensive activity in the Far East, no less than 1850 miles of new line are contemplated in Yugoslavia and about 1200 in Asia Minor. A train ferry was put in service between Great Britain and France in October, 1936, providing direct passenger and freight service.

Generally speaking, modern requirements in the design of railroad vehicles are placing inexhaustible problems before the railroad mechanical engineer. The development which has started recently and which will be greatly enhanced by the current rise in traffic receipts—now more pronounced in the United States than elsewhere—may well prove to be the most fruitful in railway history.

SELECTION *of* ENGINEERING STUDENTS

By R. L. SACKETT

DEAN OF THE SCHOOL OF ENGINEERING, THE PENNSYLVANIA STATE COLLEGE

PAST experience and present tendencies indicate that there is going to be an increasing number of applicants for an engineering education in the next few years. What can be done to raise the quality of those admitted? In the "Report of the Investigation of Engineering Education," Vol. 1, p. 25, it is stated that "nearly one fifth of all students entering (engineering schools) in 1924 were admitted with entrance *conditions* and that one eighth were conditioned in mathematics." It is probable that these figures have been decreased, and under the urge of the accrediting program of The Engineers' Council for Professional Development we may expect a more rigorous adherence on the part of the schools to these published standards of scholastic requirements.

What about mortality? On page 26 of the S.P.E.E. report, previously mentioned, it was stated that "of every 100 students entering engineering curricula approximately 38 survive to graduate and 28 complete the course regularly in the specified time."

The S.P.E.E. report also showed that some 40 per cent of entering freshman engineers did not return at the beginning of the second year. Recent studies of eight large, medium, and small engineering schools showed an average loss of 16.5 per cent before the opening of the second year; the range is from 13.5 per cent to 22 per cent. These data indicate that there must be an improvement in one or more of the following contributory factors, guidance, selection, orientation, and personnel advisory practice, if it is assumed that there is to be no lowering of standards of grading.

The fact is that more students withdraw voluntarily than are dropped for poor scholarship or other reasons. Failures and withdrawals from engineering the second year emphasize the fact that high-school students do not receive the guidance necessary to make a wise choice of a vocation.

Thus the need for better vocational guidance has been pointed out, but little was done about it until "Engineering—a Career, a Culture" was published by The Engineering Foundation.

The Committee on the Selection and Guidance of Engineering Students of the Engineers' Council for Professional Development is suggesting to the engineering schools and colleges that they take a more active part in vocational counseling, and the professional engineers are being organized through the local sections of their engineering societies for the purpose of assisting the high schools in a fuller measure of guidance to those who are considering an engineering education.

There remains the problem of selective methods. Some state institutions are required to admit all graduates of accredited schools, residing within the state, who apply. Other state and privately endowed institutions admit on certification or depend on college-entrance examinations. A few, such as Stevens Institute of Technology, Worcester Polytechnic Institute, and Lafayette College, conduct summer camps for the guidance of prospective engineering students, and thus are able to place the aptitudes required for satisfactory achievement before the student in a more effective manner. A few receive students from selected high schools and preparatory schools of high standing.

Few engineering colleges use any type of selective test which is designed to measure aptitude and preliminary training. The value of some discriminative methods was emphasized in the S.P.E.E. report and cannot be doubted by anyone who has had experience with even the most elementary methods. For instance, experience shows that acceptance of those whose high-school average for four years places them in the upper two-fifths of their class eliminates some students of poorer scholarship. If aptitude and training tests are given in mathematics, physics, and English to those of lower rank, a still further selection may be made which admits some students of ability who have not found themselves earlier in their high-school experience.

The grade of a student in descriptive geometry has been found to have high value in predicting his average in all subjects for the freshman year and also his average for the four-year engineering curriculum.

It will be helpful if a test can be developed which may be given to high-school juniors or seniors and which will measure the same quality or qualities that descriptive geometry now tests. No such test has yet been tried on prospective engineering students and then correlated with a measure of achievement such as the average grade of the student in all subjects of the first year or of the four years of engineering study. A good correlation has been shown between the average grade for the first year and for any other year or for the four years.

A selective test is much to be desired as a guidance mechanism for use in high school to supplement the Strong or Bernreuter tests of interests and as an aid to colleges which desire a selective test to insure a more homogeneous and able student body and to reduce the number who withdraw from college because they do not have the necessary qualities.

No test so far investigated is an adequate basis on which to accept or reject a student, but the cooperative test in mathematics furnishes valuable evidence on which to base confidence or doubt. We need other tests to supplement it and to foreshadow still further success or failure. With the help of specialists in discriminative testing and the support of the engineering colleges, reliable methods of gathering information concerning the student may be devised, tested, and made available to those who desire to set standards of quality for admission.

In order that selection on the basis of high-school average grades may be discriminating and just it is necessary to rate schools, and this can be done on the basis of past experience with students admitted from such schools. Students in the third fifth of some high schools may be better prepared in general to pursue a college course than those from the top fifth of some other school. Certain well-known preparatory schools rate very high as a result of long experience. By rating schools on the basis of experience, differences in relative grades may be eliminated to some, or a considerable, degree.

So far as it is expedient, the engineering colleges should use such means as are available to improve guidance in the high schools, especially those in small communities.

In order to select the better students there should be more emphasis on the aptitudes and qualities desired for solid advancement in engineering education. Such selective devices as we have should be used in order to discourage those less well-fitted, if we are to obtain the best students for engineering.

Chance for Survival of
SMALL SOUTHERN INDUSTRY

By F. L. WILKINSON, Jr.

UNIVERSITY OF TENNESSEE, KNOXVILLE, TENN.

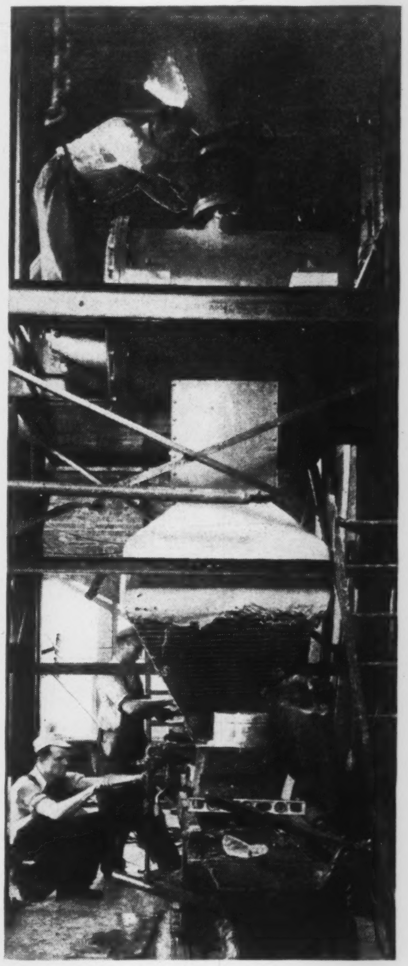
TO EXPECT that political victories can long keep one part of the country industrially dormant, while another reaps a permanent advantage from spoils gained is beyond the range of reason. Nor can industrial growth through such unstable factors be healthy and secure.

Industrialists and business men haunt the legislative halls at Washington demanding preferences and boons designed to bring to them a temporary and unhealthy competitive advantage. We have heard much in the last few years of the great disadvantage our southern industries suffer under the yoke of preferential freight rates and ruinous processing taxes.

Granting that these conditions exist, they should, to my mind, aid to a certain extent in making southern industries the leaders in their fields. They should stimulate an unprecedented effort in a march to industrial supremacy of a healthy and permanent nature.

Monopolies of any nature generally tend toward industrial stagnation. Certain industries in the South for decades enjoyed advantages in labor and raw materials that almost stifled competition. While freight rates still existed on the finished product that were preferential to competing areas, other advantages enjoyed in labor and nearness to raw materials maintained this industrial supremacy. Mills grew in size and output, but this growth was rarely in the nature of improved methods and processes of manufacture. Industrialists sat back on their haunches and worshipped the gods that gave them big orders and fat dividends.

Many competitors in other areas went under, others moved to the South to enjoy nature's blessings, and some remained in their old environment and prospered. Faced with the disadvantages of their environment, those industries that refused to move were stimulated to revolutionize methods of production and to take stock of their faults, to eliminate waste, and to introduce new and worth-while schemes of management. They not only survived and met otherwise ruinous competition, but also were in a position to derive the greatest possible benefit from the swing in natural advantages that finally came their way with the mass-scale production of a better raw material at a considerable distance from the southern industrial development.



COTTONSEED PROCESSING MACHINE IN A LABORATORY AT UNIVERSITY OF TENNESSEE

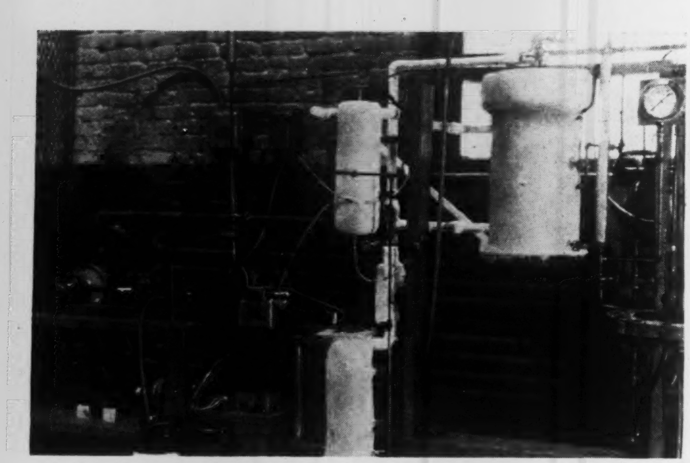
Today those southern industries are no longer blessed with the best of raw materials at their very door. Organization of their labor and a sense of social responsibility have forced a closing of the gap between the sectional pay scales. Many of them are now paying the price of the lassitude that comes from a feeling of security founded on advantages other than those of wide-awake industrial development. Some of these once prosperous enterprises are now almost completely shut down, except for seasonal spurts of activity. Others are registering bitter complaints against the injustice of a political system that permits differentials in freight rates to present their competitors with advantages that were not given them by nature. And a few, like their brothers of the East, are "turning to" and taking stock, meeting competition through improved production methods, processes, and management.

Industry is never secure and let us hope that it will never become so. For a nation or an area to feel too secure in its supremacy over other nations and areas is not good economically or socially. Political advantages will be sought and won by one area at the expense of another, and the root of this evil is too firmly implanted to picture its death except with the coming of the millennium.

Of course, such conditions are deplorable and tend toward undesirable economic unbalance. Yet wide-awake progressive industries are capable of surmounting these difficulties, and some are stimulated to such efforts that new leaders are developed in the industrial field.

While many of our southern industrialists realize the impermanence of their immediate endeavors, these are all too few in number for the industrial future of the South. The years that have followed the Civil War have seen a shift in the dependence of its people. The dependence no longer rests on agriculture but is largely divided between agriculture and industry. That should be a healthy situation.

Presented at the Industrial Meeting of the Knoxville Section, of The American Society of Mechanical Engineers, May 12–13, 1936, Kingsport, Tenn.



MANGANESE RESEARCH APPARATUS AT UNIVERSITY OF TENNESSEE

What industries have prospered in the last five years? The fact is well-known that the chemical groups have never experienced a prosperity as great as that in the years when others failed or floundered. That the chemical industries have prospered has not been due to any political advantages as to labor, taxes, or preferential freight rates. For the most part they have had bountiful years irrespective of location in the South, North, East, or West. Establishments in this field have also prospered irrespective of size.

No industry can afford to consider that its life is long. And the very fact that the chemical industries realize that theirs is perhaps the shortest-lived, indicates that the more insecure we believe ourselves, the better our chances for a more permanent life at the old stand. One chemical manufacturer has made the statement that the success of his enterprise has been built on the policy that no process developed and no article manufactured can be a money-maker for more than four years. At the end of that time, a way of doing the job more economically or a new article to take its place must have been developed.

The South has gained certain advantages through New Deal legislation, some of it at the expense of other parts of the country, and some in common with the rest of the nation. But legislative boons and panaceas cannot take the place of industrial alertness in the actual processes of manufacture. This means continued development work, industrial research, engineering technique, as well as wide-awake internal management.

No excuse exists for Big Industry's failure to meet these needs. But what about Small Industry's opportunities? It certainly cannot stand the overhead and relatively high cost of expensive technical research in the face of mass production, without possession of monopolistic processes. Yet, such efforts would seem necessary.

STATE UNIVERSITIES CAN AID SMALL INDUSTRIES

The state universities of the country have at hand the facilities in men and much of the equipment necessary to carry on research and development work in all lines of industrial processes. Industrial development requires technical knowledge in the fields of physics, chemistry, bacteriology, electro and physical chemistry, chemical engineering, electrical engineering, mechanical engineering, and metallurgy, together with all of their allied natural and applied sciences. Among their faculties and graduate students can be found all elements of a complete industrial, scientific, and engineering staff.

The fear of the label of competing with private enterprise has frequently held these institutions back from offering to industry anything but basic research developments of a general nature. Yet, they can do this, especially in the South, without entering into competition with commercial enterprises of a similar type, because private establishments that can offer to small industry much more than a limited amount of help as consultants on specific problems do not exist.

An engineering experiment station of this proposed nature should not aim to enter the field of the consulting engineer or of the testing laboratory. Its purpose should be to fill the need of the smaller industry in preparation for the future by developing new processes, new products, and new machinery of production on an economical basis. An institution of this nature could well afford to offer to its client industry the exclusive rights to developments made in the pursuit of its subsidized project. The cost to industry should include only the actual development cost, plus a small overhead covering administration. Small industry needs this aid if it can expect to survive in the face of competition with larger ones whose very size makes it financially possible for them to support just such organizations as a part of their individual production machinery.

Even where state institutions of learning may be backward in offering this assistance, taxpaying industrialists have the right to demand a return in service. In most states they are by far the largest source of governmental income. The farmer has been told so often that his property taxes are too high that he now believes it and is succeeding in demanding and receiving tax reductions. While his land taxes are being reduced, the state universities, through national and state subsidy, are offering him more and more assistance.

In one state in the South, the agricultural experiment station receives more funds for one year's operation than does the entire state university for two years. Thus, the knowledge derived from research in agriculture is available for use by all agriculturists, and monopolies or competitive advantages cannot be enjoyed by one farmer at the expense of another through the efforts of the agricultural experiment station.

An engineering experiment station, operating on a like plan obviously could not gain the support of industry but must offer to industry developments that can be used in a highly competitive industrial world. Therefore, each project undertaken must be sponsored and supported by the industry concerned; and that industry's rights protected. Thus, a statewide technical service may be developed and maintained for the benefit of those wide-awake industries that are anxious to live and to continue to meet competition in an advancing industrial world. Some institutions offer this service, but all too few small industries avail themselves of it. Those that do are profiting by the relationship.

Small industry especially should welcome change. The ratio of capital tied up in the machinery of production to the value of products manufactured is small when compared to the vast sums invested in equipment by mass-production industries. The cost to them of change is comparatively small, and the burden less in proportion. When provided with the results of research and development work, these small industries can change overnight and gain immense competitive advantages.

Sectional advantages alone cannot for long increase any industry's life. Industrial life for both small and large industry depends to an even greater extent on its ability to avail itself of the advance of science. Industry is based on science. Without it, it cannot live. Technical research is available for both big and little industry, and they can survive together if they demand and use the available sources.

The Changing Picture in
SOUTHERN PROCESS INDUSTRIES

By R. M. BOARTS

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THAT THE South is the center of a group of process industries which contributes more and more to our mode of living is becoming increasingly evident to the average newspaper reader. Of course, this is no news to the southern industrialist. Nevertheless, the picture of the southern process industries is changing so rapidly that to see where we have been and where we are now is not always easy. Processing as a whole will develop rapidly—we are sure of that—but whether the unit of the process industries in which you or I are most interested will prosper will depend on how successful we are at mixing experience with vision.

For the purpose of our discussion, defining the term "process industries" would be wise. While this cannot be done very successfully, let us say that the process industries are those in which the physical and, usually, the chemical properties of the processed material undergo marked change. This is in contradistinction to the fabricating industries which are concerned with the shaping, finishing, and other mechanical operations necessary to make a marketable object. This definition is very loose. The manufacture of salt is usually called a process industry, although no chemical change has been made in the salt from start to finish. Steel and iron production, on the other hand, is not usually considered a process industry. It stands on its own feet as a separate entity. The term "process industry," then, is a matter of custom. We say that the production of rayon is a process industry, but the weaving of the rayon thread into cloth is a fabricating or mechanical industry.

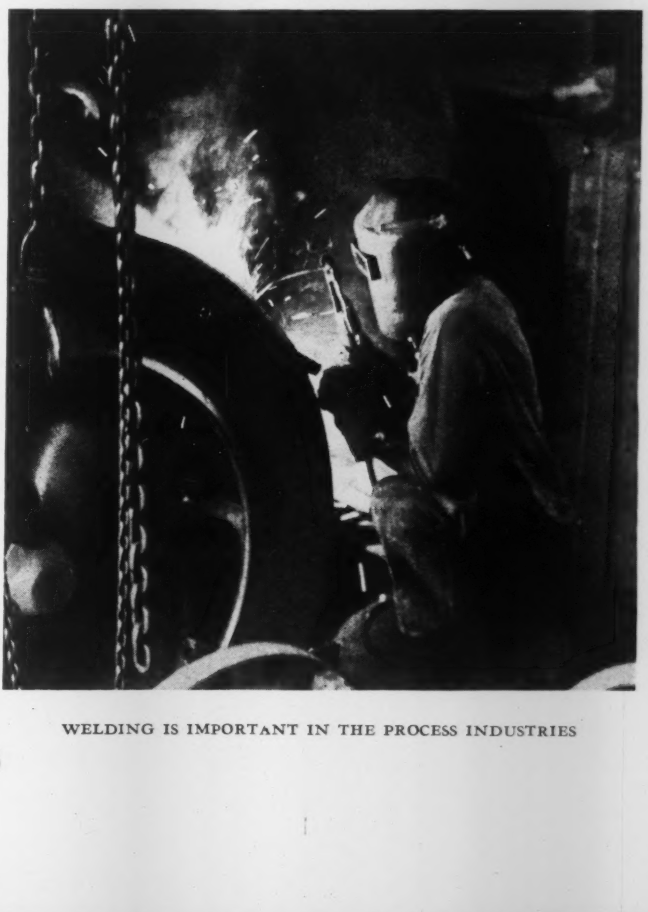
SOUTHERN PROCESS INDUSTRIES BEGAN IN 1608

The southern beginnings of the process industries antedated the World War. In 1608, the London Company sent out workmen to undertake the manufacture of glass, pitch, and tar in Virginia. It was a bitter struggle, and the end came soon after John Rolfe began to cultivate tobacco in 1612. We find here, for the first time in the South, the displacement of the process industries by agriculture. Today, we are in the last part of this phase. Tomorrow, agriculture will see a progression from the fields to the process industry to the fabricating industry that makes for a regional prosperity far greater than that in the days when cotton and tobacco were kings.

For many years, the South has had significant chemical industries based on mineral raw materials. The copper development made, as a by-product, sufficient sulphuric acid to control the acid price situation in the large southern fertilizer markets. This by-product acid has been a determining factor in prices at St. Louis and Chicago, and to a lesser extent at New York. Phosphate rock was discovered in South Carolina in 1865 and in Florida in 1888. In Tennessee, the phosphate deposits came into production in 1893. These deposits furnish practically the world's supply of phosphatic materials, and the fertilizer industry used approximately one-half of all sulphuric acid produced in the manufacture of superphosphate. This too, was no war baby—the gross sales of fertilizer before the war were over 75 million dollars annually.

As yet, the process industry of fertilizer manufacture served agriculture, but agriculture did not serve the process industry. The cotton of the South went directly to the textile mills, which was predominantly a fabricating industry located outside the area. This was an unstable condition which was partially relieved when textile plants began to move to southern locations. But more spinning plants will not solve the problem of larger supply than demand, nor will the persistent cry that the government do something for cotton.

It remains for a changed agricultural program and the process industries to do something for cotton. Already, the rayon industry is a new giant in southern industry, but its blessings may not fall altogether on cotton. Not only can cotton linters be used as a source of cellulose for rayon, but wood pulp also can be used and is the predominating raw material. This industry, which entered this country in 1910, has steadily reduced the ratio of consumption of cotton to rayon from 340 to 1 in 1920 down to 13 to 1 in 1934. At the same time, the quantity of rayon used increased to approximately the same amount as wool, and about three times that of silk. So far,


WELDING IS IMPORTANT IN THE PROCESS INDUSTRIES

Presented at the Industrial Meeting of the Knoxville Section, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, May 12–13, 1936, Kingsport, Tenn. Abridged.

the consumption of cotton fiber has not been decreased. Rayon has served as a supplementary fiber.

RESEARCH AND DIVERSIFIED PRODUCTS NEEDED

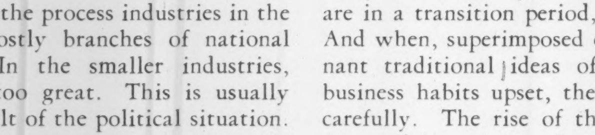
At first sight, the only prospect ahead would seem to be a bitter struggle for possession of this single class of products—fibers. This is where the process industries have their greatest strength and their weakness. Once the process engineer sees his reactors and autoclaves working, he is possessed with the desire to make other products. This done, it is not a life-and-death matter to be fought with tariffs and laws to protect a single product. Motion-picture film, or cellophane, or synthetic plastics, or any of a thousand other products help diversify this industry. At the same time, new processes or new products may entirely wipe out a profitable market. A still newer product must be provided to take the place of that superseded. This, then, is the economics of the process industries which are even now a large part of southern industry. Their doctrine is one that recognizes the impermanence of last year's best selling product, and their creed is research.

Despite the uncertainties caused by the tax systems—or rather lack of tax systems—the process industries have been expanding at a terrific rate in the Southern states. Likewise, the smaller industries that do not meet the public eye are increasing, but there should be far more of them. They possess competitive advantages in their ease in changing their production and their products which a large industry does not have. On the other hand, they most of all are apt to forget that progress in new development work is essential to the life of an industrial business. This is the pressing need of southern industry.

This is our own present state of the process industries in the South. The large industries, mostly branches of national organizations, are flourishing. In the smaller industries, confidence in the future is not too great. This is usually carefully explained as being a result of the political situation. Whether this is true or not does not matter greatly. We must have not only southern branches of national industries but also smaller local process industries—and they must all prosper together.

FACTORS AFFECTING THE FUTURE

Thus, we approach the future of the process industries of the South. One of the first facts bearing on the prosperity of the process industries is that they influence and are influenced by the fabricating industries. The rayon yarn must be made into cloth, the soybean and other plastics follow the automotive and radio demand, the aluminum must be fabricated before being sold to the consumer. This, I believe has been recognized by every one. The other corollary—that the mechanical industries lean upon the process industries—has not been so publicized. What we know as the mechanical revolution, usually exemplified by the mechanization of the textile industry, would have died of strangulation if the process industries had not developed means for rapidly bleaching and finishing the cloth. Under hand-spinning and weaving production methods, a piece of cloth was months being bleached and finished for market. With a flood of cloth from new looms, processing had to meet the crisis, or both mechanical and process industries would have failed. So it is that the mechanical industries of this country must thrive, for the process industries generally follow rather than promote demand.



A second factor influencing the prosperity of the southern process industries is the same agriculture that had squeezed out the factories three hundred years earlier. When we consider the tremendous energy transfer on the farm, we see that agriculture is simply a big-scale process industry manufacturing alpha-cellulose, varnish solvent, salad oil, or hundreds of other products. Every minute of sunlight delivers to each square foot of area 6 Btu of heat energy. If the farm, working with the process industries, will grow crops that are readily convertible into salable products, then a balance will result which will be particularly favorable to southern prosperity. The danger lies in the fact that the farmer has never been noted for his flexibility of action. If alpha-cellulose of satisfactory grade is produced by wood pulp cheaper than from cotton, then the farmer must be prepared to abandon cotton. This versatility is almost too much to hope for. He will probably grow unwanted cotton, and then cry for legislative subsidy like his larger and more experienced industrial brothers.

Yet, hope exists in this field. The soybean, the tung-oil nut, and other agricultural crops, which were unknown to the southern farmer a few years ago, are now widely discussed. The problem is one of education and organization similar to but more extensive than that faced by beet-sugar processors in their early struggles in the mid-western states.

The third factor is one that is not regional only, but national. The old concept of the economic man and his effect on business is largely lost in the complicated maze of regulation put upon us by tariff, subsidy, laws, edicts, cartels, and what not. We are in a transition period, whether we approve of it or not. And when, superimposed on this confusion, we see our dominant traditional ideas of the permanence of time-honored business habits upset, then we should consider the situation carefully. The rise of the process industry has emphasized the need for quick action, for large production changeable at short notice, for new processes and new products, for vision and courage. Large quantities of energy are needed. The tremendous reservoir of unskilled labor in the South that chambers of commerce are so quick to point out to prospective employers is not generally a large consideration in the process industries. The cost of obsolescence and depreciation is a large consideration. The cost of research and development is a major item. These are all factors that have made our changing picture so noticeable to every one.

Obviously, manufacturing a product will yield no profit unless it can be sold. The business of supplying the necessities of life would be badly overcrowded except for the fact that the list of necessities of life is being expanded every day. The process industries must supply new materials to the fabricating industries and new products to the people of the nation. Agriculture, forestry, and mining must supply raw materials to the process industries. The fabricating industries must supply their products cheaply to the people so that they can buy, not only for their necessities, but also for their luxuries. Today, the changing picture of the southern process industries is warning us that southern prosperity cannot depend on agriculture, or on the fabricating industries, or on the process industries, but on the successful integration of all three.

WORKING *of* NICKEL-BASE ALLOYS

Heat-Treatment, Machining, and Welding of Monel, Nickel, Inconel, and Hastelloy

By F. L. LaQUE

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THE PROCEDURE for heating nickel-base alloys prior to hot-working differs from that commonly used with steel. The metals must be charged into a hot furnace, not heated up with the furnace. They should not be soaked but should be removed from the furnace on a rising temperature, care being taken to avoid overheat. Uniformity and speed of heating are facilitated by supporting the work on riders that will allow circulation of the hot gases around the material to be heated.

Controlling the furnace atmosphere and keeping it on the reducing side, as represented by the presence in the atmosphere of at least 2 per cent of carbon monoxide, are preferred. The fuel used should be practically free from sulphur, 0.5 per cent as the maximum, and coal and coke are not recommended for this reason where other fuels are available. The material itself should be free from the lead or sulphur compounds sometimes used for lubricants in drawing and machining.

The proper temperature ranges for hot-working are monel, 2150 to 1600 F; nickel, 2250 to 1250 F; and Inconel, 2300 to 1600 F. The best temperatures for bending are 2250 to 1900 F for all materials.

The amount of hot-working must be decreased as the temperature falls. More power is required for forging than for steel, and the recommendations of die-steel manufacturers should be followed in choosing die materials. For drop forging and pressing, heavy grease and graphite are useful lubricants, and sawdust helps to prevent sticking.

COLD-WORKING SIMILAR TO STEEL

In general, the practice for these materials is similar to that used with steel. When doing deep drawing with a double-action press, the diameter reduction on the first draw may be from 30 to 35 per cent, with 20 to 25 per cent allowed on redraws. With a single-action press, the first draw should not give more than 20 per cent diameter reduction. Where the diameter reduction is less than 5 per cent, the wall thickness may be reduced as much as 30 per cent.

Satisfactory die materials include cast iron, preferably of the heat-treated nickel-chromium type; hardened and chromium-plated steel; and insert rings of hard aluminum bronze. Tungsten-carbide dies are suitable for small work. Carbon steel is definitely unsuited. A die clearance of 25 per cent of the metal thickness is suggested while the die radius should be from 6 to 10 times the metal thickness. Proper lubrication is essential; the principal precaution is to avoid sulphur or lead compounds on work to be annealed, and good practice dictates removing any lubricant prior to annealing.

Punches must be at least 75 per cent stronger than for steel, although the same clearance should be used. A sulphur-base oil cut with paraffin oil makes a good lubricant. Lubricant must be rinsed thoroughly from sheets that are to be annealed subsequently.

ANNEALING TIME MUST BE CLOSELY CONTROLLED

Close control of annealing time is necessary to avoid rapid grain growth at temperatures above 1600 F and to protect the material from sulphidization and scaling. Preparation of the work should include complete removal of any drawing compounds, paint marks, or other substances that may contain sulphur or lead. Supporting the work clear of the furnace hearth is desirable to avoid contact with scale, cinders, and similar substances.

In open annealing, where the metals must be in contact with the heating gases, combustion must be complete before the gases reach the metal, the atmosphere should be definitely reducing with not more than 5 per cent of carbon monoxide and essentially sulphur free. Suitable fuels are city gas, natural gas, butane, propane, light distillate oils, and other liquid or gaseous fuels containing less than 0.5 per cent sulphur. Electric heating in a controlled, reducing atmosphere is ideal.

Before charging the material to be annealed, the furnace should be at temperature. The following temperatures and times are suggested:

		Time at temperature, min	
Metal	Temperature, F	Mechanical operations	Hand spinning
Inconel......	1800	5–10	10–15
	1900	1–3	5–10
Monel.......	1700	2–5	5–10
	1800	½–2	3–5
Nickel.......	1650	2–5	5–10
	1750	½–2	3–5

Stress-relief annealing can be accomplished at temperatures from 575 to 1000 F for monel and nickel and up to 1200 F for Inconel.

To reduce the oxide layer that forms when nickel or monel is removed from the furnace, the pieces should be quenched in a mixture of 1 gal of wood alcohol, or denatured alcohol, in 50 gal of water. Work that has been air-cooled without such a reducing quench will carry a very thin, tightly adherent, dark, glossy film that can be removed by light rubbing with No. 00 emery.

Box annealing can be carried out in almost any kind of furnace atmosphere, using metal boxes sealed with clay or sand, packed with charcoal, and provided with means for passing a reducing gas through the box during the cooling period.

Conclusion of a paper contributed to the Symposium on Corrosion-Resistant Metals in Design of Machinery and Equipment by the Iron and Steel Division and presented at the Annual Meeting of The American Society of Mechanical Engineers, Nov. 30 to Dec. 4, 1936, New York, N. Y. The first portion of Mr. LaQue's paper, which dealt with the use of these alloys in design of corrosion-resistant machinery and equipment was published in Mechanical Engineering, vol. 58, December, 1936, pp. 827–843.

The time and temperature required for box annealing vary considerably, but the following data, which refer to time at the given temperature, can be used as guides:

Metal	Temperature, F	Time, hr
Inconel	1500	2 to 6
Monel	1400	2 to 6
Nickel	1400	2 to 6

CHARACTER OF OXIDE COATING DETERMINES PICKLING METHOD

Procedure for pickling varies considerably among the metals, according to the nature of the oxide coating to be removed; consequently, space limitations render the giving of detailed instructions impossible. A good pickle for monel and nickel bearing an oxide film contains 1 gal of hydrochloric acid of 20 Bé gravity, 2 gal of water, and $^1/_2$ lb of cupric chloride. This solution should be used at a temperature of about 180 F for 20 to 40 min with monel or from 1 to 2 hr for nickel. Monel may require brightening by a second treatment for from 5 to 10 min, at 70 to 100 F in a solution containing 1 gal of water, 0.1 gal of sulphuric acid having a specific gravity of 66 Bé, and 1.1 lb of sodium dichromate. The bright dip should be followed by a rinse in 1 per cent ammonia solution.

To facilitate the pickling of Inconel, the heating atmosphere should be controlled to avoid development of a heavy black oxide. The thinner, greenish, chromium oxide formed in mildly oxidizing atmospheres can be removed by treatment of from 15 to 90 min, at from 70 to 100 F, in a solution containing 1 gal of water, 1 gal of nitric acid of 38 Bé gravity, and 1.0 to 1.5 lb of sodium fluoride.

TABLE 1 RECOMMENDED FEEDS AND SPEEDS FOR AUTOMATIC SCREW-MACHINING OF R-MONEL

Operation	Width of cut, in.	Feed, in.	Speed, fpm
Box tool			
Roughing	$^1/_{32}$	0.00600	125
	$^1/_{16}$	0.00500	125
	$^1/_8$	0.00400	125
Finishing	0.005	0.01000	125
Cut-off tools			
Circular or straight	$^1/_{16}$–$^1/_8$	0.00100	125
Stock under $^1/_8$ in. in diameter	...	0.00050	125
Forming tool, circular	$^1/_8$–$^1/_4$	0.00060	125
	$^3/_8$–$^1/_2$	0.00050	125
	$^5/_8$–$^3/_4$	0.00040	125
	1	0.00025	125
Balance turning tool			
Turned diameter under $^5/_{32}$ in.	$^1/_{32}$	0.00600	125
	$^1/_{16}$	0.00500	125
Turned diameter over $^5/_{32}$ in.	$^1/_{32}$	0.01200	125
	$^1/_{16}$	0.01000	125

TABLE 2 RECOMMENDED CUTS, FEEDS, AND SPEEDS FOR TURNING INCO PRODUCTS

	Cut, in.	$^1/_{64}$		$^1/_{32}$			$^1/_{16}$			$^1/_8$				$^1/_4$			$^3/_8$		
	Feed, in.	$^1/_{64}$	$^1/_{32}$	$^1/_{64}$	$^1/_{32}$	$^1/_{16}$	$^1/_{64}$	$^1/_{32}$	$^1/_{16}$	$^1/_{64}$	$^1/_{32}$	$^1/_{16}$	$^1/_8$	$^1/_{32}$	$^1/_{16}$	$^1/_8$	$^1/_{16}$	$^1/_8$	$^3/_{16}$
Cutting speed, fpm	Wrought monel and nickel	170	140	115	100	85	95	80	55	85	70	50	45	55	45	35	35	30	25
	Wrought K-monel (unhardened) and Inconel	125	90	75	65	50	60	45	35	50	40	37	30	35	30	25	25	20	15
	Cast monel and nickel	135	110	90	80	70	75	65	45	65	55	40	35	..	..	..	..	..	..
	Cast H-monel	90	75	60	55	45	50	40	30	40	35	25	20	..	..	..	..	..	..
	Cast S-monel	45	37	20	27	22	25	20	15	20	18	13	10	..	..	..	..	..	..

SLOWER SPEEDS AND LIGHTER CUTS REQUIRED IN MACHINING

Monel, nickel, and Inconel are machinable. Being tougher and stronger than mild steel, cutting speeds must be slower and cuts lighter. The cutting tools should be made of tough high-speed steel, 18-4-1 type, hardened to about 65 Rockwell C, and with the cutting edges ground to sharper angles than for steel. Honing of the tools is recommended. Sulphurized oil should be used freely as a lubricant for boring and drilling and is preferred for general work, although water-soluble oils will suffice for lathe work. A special type of monel that can be machined at high cutting speeds is available for automatic screw-machine work. This is known as R-monel. Table 1 gives suggested feeds and speeds for automatic screw-machining of this metal.

Tools for cutting monel differ from those ground for cutting steel in that a slightly larger true-rake angle back from the cutting edge is required. This holds true for all cutting tools. A good lathe tool for medium cuts will have the following angles: Back-rake angle, 6–8 deg; side-rake angle, 15–18 deg; side clearance, 6 deg; end clearance, 8–12 deg; and nose radius, $^1/_{16}$ to $^3/_{16}$ in., depending on the depth of cut.

With K-monel and Inconel, the clearance angle should be kept at the minimum, and, for heavy working, grinding a small land of about $^1/_{32}$ in. at the cutting edge is advantageous. Data on suggested cuts, feeds, and speeds are given in Table 2.

Standard twist drills as furnished by their manufacturers have proper angles for general-purpose work. Only high-speed or superhigh-speed steel drills should be used, and polished flutes are preferable. Sulphurized cutting oils give best results. The recommended speeds for regular monel and nickel are between 40 and 60 fpm with the same feeds as those commonly recommended for mild steel. R-monel can be drilled at a speed of from 60 to 75 fpm. Lowering the drilling speed to between 30 and 45 fpm for Inconel, and to between 20 and 30 fpm with 75 per cent of the standard feed for soft K-monel is necessary.

Reamers must be kept sharp at all times. Speeds are approximately from 25 to 30 fpm for monel and nickel, and about 10 to 15 fpm for K-monel and Inconel. Feeds are approximately twice the recommended drill feed for the same size of hole.

For general practice in milling monel and nickel, an average cutting speed of from 50 to 65 fpm with a feed of from 0.005 to 0.010 in. per tooth, depending on the depth of cut, is usually satisfactory, assuming, of course, that the setup is favorable. With Inconel and K-monel that has not been heat-treated, the surface speed of the cutter must be reduced to approximately 40 fpm with a feed of from 0.003 to 0.006 in. per tooth.

Regular monel and nickel can be tapped at a speed of from 20 to 25 fpm. K-monel that has not been heat-treated and Inconel can be tapped at approximately 12 to 15 fpm. Grade R-monel can be tapped in automatic machines at a speed of from 25 to 35 fpm.

WELDING, SOLDERING, AND BRAZING

For oxyacetylene welding, the flame should be slightly reducing, and Inco gas-welding and brazing flux should be used with monel but not with nickel. Borax should not be used as a flux. The weld metal should not be puddled or boiled, and, with proper procedure, the pool of molten metal should be quiet. The welding rod should be of the same general composition as the material to be welded, and can be obtained from the same source. The size of welding tip is a matter of personal choice, but ordinarily one tip size larger than recommended for the same gage in steel is preferred.

Metallic-arc welding should be carried out with reversed polarity; work negative, electrode positive. The proper rod with a suitable flux coating can be obtained from the same source as the material being welded. The welding rod flows readily and freely, and welds are sound and free from cracking either in themselves or in the adjacent metal. Complete penetration of a single bead from one side is possible in gages up to about $1/8$ in. In welding light gages, 0.109 in. and less, no oscillation of the rod is required, but, with heavier gages weaving or oscillating the rod is advisable. The flux coating that covers the finished weld can be removed readily by drawing the edge of a flat chisel along the edge of the weld.

Carbon-arc welding should be done with straight polarity, and, in general, the practice follows that described for oxyacetylene welding. The correct rod can be obtained from the source of the metal. The carbons should be $1/4$ in. in diameter or smaller and tapered for 2 in. Good practice requires the use of relatively low heat with no puddling. A copper backing is useful. This method gives good results, including excellent and uniform penetration and is especially useful for gages under $3/16$ in., on short seams and for joining pieces of unequal cross section.

Any spot-welding machine can be used. Compared with steel, the pressure should be lighter, the current higher, and the time shorter. With proper procedure, excellent results are obtained. For seam welding, the general procedure is the same as for spot welding, and good results are being obtained on lap seams in gages up to 0.093 in.

In soft-soldering lock seams or other joints, the edges should be tinned, using an iron in preference to a torch. Either high or low-tin solders can be used successfully. In many cases, the surfaces to be joined should be cleaned with emery cloth. Several fluxes can be used, including the common zinc-chloride base mixtures. Sufficient heat must be provided, either with an iron or the torch, to insure complete penetration of the solder. This may require slower manipulation of the iron than is customary with other metals of higher heat conductivity.

Silver solders that melt below 1350 F are preferred. The metal should be heated with a small oxyacetylene torch sufficiently to get the solder to flow freely, and the flame should be kept moving. For Inconel, the best type of solder is that typified by Handy and Harman's Easy Flo, with which Handy flux is used. This flux improves the flow of the solder and avoids discoloration of the metal. Most brazing rods are satisfactory and can be used with the Inco gas-welding and brazing flux.

HASTELLOY ALLOYS MACHINE EASILY AND WELD READILY

The A and C grades of Hastelloy are machinable by ordinary methods. Sulphurated threading oils are very good coolants and lubricants for drilling, tapping, and threading operations. Turpentine is recommended for drilling small holes in Hastelloy C. White lead and cutting oil are used for tapping both Hastelloys A and C. Haynes Stellite No. 3 and J-metal tools are excellent for machining these alloys.

Proper feeds and speeds cannot be set down for all purposes, since these will vary with the nature of the work to be done. The data given in Table 3 cover average conditions, and, while increasing the speed is possible, this is usually inadvisable since tool life and general efficiency will be sacrificed.

The Hastelloy alloys weld most readily using the oxyacetylene torch, and the electric-arc method is also satisfactory. For the former, a neutral flame must be maintained, as any excess of acetylene increases the carbon content of the weld, thus impairing the corrosion-resistance of the weld. Where the corrosion conditions encountered are very severe, welding with the electric arc is preferable to the oxyacetylene torch, due to an almost inevitable slight carbon increase with the latter method. Due to carbon increase, the metallic arc must be used for electric welding rather than the carbon arc. For welding wrought parts, no general preheating is required, and a localized preheating is sufficient for small castings, but, for large castings, a general preheating is usually necessary to prevent heating and cooling strains incidental to the welding operation. To lay down any specific rule for welding all classes of Hastelloy is difficult, as this will necessarily depend upon the nature and size of the part to be welded.

TABLE 3 RECOMMENDED SPEEDS FOR MACHINING HASTELLOY

	Rough turning, facing, and boring	Finish turning, facing, and boring
Speed, fpm		
Hastelloy A	50–60	60–70
Hastelloy C	30–40	35–50
Feed, in.		
Hastelloy A	0.025–0.035	0.015–0.020
Hastelloy C	0.020–0.030	0.012–0.018
Depth of cut, in.		
Hastelloy A	$1/16$	$1/32$
Hastelloy C	$1/16$	$1/32$

Wherever possible, welded parts of wrought Hastelloy A should be annealed by heating the entire structure to 2150 F, holding this temperature for a short time, according to the thickness of the material, and cooling rapidly in air or water. This is very important where severe corrosion service is to be encountered, as it eliminates the possibility of corrosion in the base metal adjacent to the weld and imparts the maximum corrosion resistance to both base and weld metal. Welded castings of Hastelloy A and C are also put into the best condition for corrosion service by annealing at 2150 F and cooling rapidly, but the beneficial effect of this treatment on castings is much less than on wrought material. In the case of Hastelloy D, the welded article should be heated to 1600 F and allowed to cool very slowly to atmospheric temperature, preferably in a furnace.

In electric-arc welding, best results are obtained by using reversed polarity with a current of from 100 to 125 amp. The welding rod should be flux-coated and of the same general composition as the metal to be welded. Oxyacetylene welding is preferred for use on castings, although many fabricators of Hastelloy A sheet and plate prefer the electric-arc method. A special flux for oxyacetylene welding is available from the producer of Hastelloy. Cast welding rod can be supplied in all of the Hastelloy grades, either plain or flux-coated. Hastelloy A is also available in the form of drawn welding wire.

Hastelloy A may be worked either hot or cold, but cold work should be accompanied by frequent annealing at from 2100 to 2150 F, followed by as rapid cooling as possible in either air or water.

Hot forming should be carried on only in the temperature range from 2150 to 1850. Between 1650 and 1300 F, the alloy loses ductility, especially if held for long periods in this range, or if cooled through it slowly. Hastelloy A is exceedingly stiff, even at high temperatures, and care should be taken to carry out forming gradually so that the metal will flow and not tear.

(Continued on page 181)

UNEMPLOYMENT *of the* ENGINEER

Second Series of Results of the Survey of the Engineering Profession Conducted by the U. S. Bureau of Labor Statistics

RESULTS OF a study of the engineer's education made public some time ago[1] by the United States Bureau of Labor Statistics constituted the first of a series of summary reports on a survey of the engineering profession. The Bureau initiated the survey in May, 1935, at the request of the American Engineering Council, when a questionnaire was mailed to 173,151 engineers. One question called for employment status on each of three dates, thus giving a cross section as to employment, unemployment, work relief, and direct relief on Dec. 31, 1929, 1932, and 1934. The studies reported in the present article, second of the series, are based on replies to this question on employment status. The statistical tables and the text which follow have been taken from the Bureau of Labor Statistics' summary report.[2]

The survey showed that, at the end of 1932, more than one tenth of the engineers were simultaneously unemployed; that, at one time or another between the beginning of 1930 and the end of 1934, more than one third of the engineers had some period of unemployment; and that half of those who became unemployed were out of work for more than a year.

From the 52,589 reports from professional engineers throughout the country, the following summary analysis of unemployment, including work relief and direct relief, may be presented:

(1) Between the end of 1929 and of 1932, the percentage of engineers who were unemployed increased from 0.7 to 10.9. At the end of 1934, the percentage was 8.9.

(2) At no time was direct relief extensive among engineers, but the development of work-relief programs after 1932 became an important factor. Although 10.9 per cent of all engineers reporting were unemployed on Dec. 31, 1932, less than one fifteenth of those unemployed were on work relief. On Dec. 31, 1934, 4.0 per cent of all engineers reporting had work relief, that is, almost half of the total number of engineers unemployed at that time.

(3) The largest number unemployed at any one time was about 11 per cent of the total, but more than a third of the engineers had some period of unemployment between 1930 and 1934.

(4) Among those who became unemployed at some time within these 5 years, half were out of employment, except as they found work relief, for more than a year.

(5) This experience with unemployment was common to all professional classes of engineer. In 1932, unemployment ranged from 10.1 per cent among chemical and ceramic engineers to 11.6 per cent among electrical engineers. In 1934, approximately 8 per cent of the electrical, mechanical and industrial, and the mining and metallurgical engineers were unemployed. The percentage of unemployment dropped most among chemical engineers, of whom 6.8 per cent were unemployed in December, 1934. Unemployment among civil engineers showed a slight increase from 1932 to 1934.

(6) The most marked differences as regards unemployment are those found among the various age groups. The greatest frequency of unemployment was among those who attempted to enter the profession after 1929. Approximately half of them were unemployed at one time or another from 1930 to 1934. Older engineers, who were already professionally established prior to 1929, were less frequently unemployed, although, even among those with 20 or more years of experience, one quarter had some unemployment.

(7) When the older engineers became unemployed, however, unemployment lasted longer than with the younger engineers. Thus, the median period of unemployment for engineers graduating in 1925–1929 was 12.1 months, whereas the median for those graduating prior to 1905 was 23.1 months.

(8) The effect of this longer period of unemployment among older engineers was cumulatively to produce a higher percentage of unemployment among older than among younger engineers. Thus, in December, 1934, 11.5 per cent of the engineers 53 years of age or more were unemployed, in contrast to an average of 7.3 per cent of the younger engineers who were exposed for the same period to the risk of possible unemployment.

(9) The type of education the professional engineer had received did effect variations on both the incidence and severity of unemployment. These factors were very much less for postgraduates than for engineers with other types of education. But as between engineers with first degrees in engineering and those whose college course was incomplete or who had attended noncollegiate technical schools, the differentials were very slight.

(10) The influence of regional location on unemployment was practically negligible, whether considered from the point of view of differentials in incidence or of severity of unemployment.

In what follows, some of the more significant statistical tables and comments on them are quoted. Data as to the relationship to unemployment of the education received and the age of the engineer are to be found in Tables 1 and 2.

Analysis of trends shows that (*a*) a distinct improvement in the unemployment status of professional engineers between Dec. 31, 1932, and Dec. 31, 1934, was found, (*b*) the differences in the incidence of unemployment among the various professional classes in 1932 and, except for civil engineers, in 1934 were but slight, (*c*) engineers who had received postgraduate degrees fared better than those with other types of training, and (*d*) as between older and younger engineers, the former not only felt the effect of the drop in business activity earlier than the latter but also unquestionably were still lagging, at least until Dec. 31, 1934, in the return to professional activity. Generally speaking, in this period of contraction of business activity, the inexperienced newcomer had greater difficulty in securing a professional status than any other class. Those with from 5 to 25 years' experience fared best as regards unemployment, and little difference, except in the case of chemical engineers, was noted in the percentages of unemployment at a given date between those with less than 5 and those with more than 25 years' experience.

More than 35 per cent of all the engineers reporting were unemployed at one time or another between Jan. 1, 1930, and Dec. 31, 1934, as against about 11 per cent who were unemployed on Dec. 31, 1932. The percentage who reported unemployment at some time within these five years with a classification by age and type of education, is shown in Table 3. For all graduates combined, including those with postgraduate degrees, no less than 37.8 per cent experienced unemployment. This percentage differs but slightly from the general average of 35.4 and 35.6 per cent, respectively, for engineers who did not

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[1] "Education of the Engineer," MECHANICAL ENGINEERING, August, 1936, pp. 505–509. "Educational Qualifications in the Engineering Profession," *Monthly Labor Review*, June, 1936, pp. 1528–1542; also reprinted as B.L.S., Serial No. R. 400.

[2] "Unemployment in the Engineering Profession," prepared by A. F. Hinrichs, chief economist, and A. Fraser, Jr., Division of Wages, Hours, and Working Conditions, Bureau of Labor Statistics, *Monthly Labor Review*, January, 1937, pp. 37–59.

TABLE 1 PER CENT OF ENGINEERS OF EACH PROFESSIONAL CLASS UNEMPLOYED[a] ON DEC. 31, 1929, 1932, AND 1934, BY TYPE OF EDUCATION

	Per cent unemployed on Dec. 31											
	1929				1932				1934			
			Others with				Others with				Others with	
Professional class	Post-graduates	First degree graduates	College course incomplete	Noncollegiate technical course	Post-graduates	First degree graduates	College course incomplete	Noncollegiate technical course	Post graduates	First degree graduates	College course incomplete	Noncollegiate technical course
All engineers	0.5	0.7	0.9	1.1	8.1	11.5	10.4	11.1	6.3	9.1	10.3	10.0
Chemical and ceramic	0.0	0.4	1.6	0.0	6.5	11.3	7.9	25.0	3.2	7.7	5.8	23.8
Civil, agricultural, and architectural	0.5	0.7	0.8	1.4	9.4	10.8	10.2	11.7	9.6	10.9	11.9	13.3
Electrical	0.8	0.3	0.6	1.4	8.5	12.5	9.6	10.3	5.7	8.2	9.3	8.6
Mechanical and industrial	0.5	0.8	0.9	0.4	6.4	11.8	11.9	10.5	4.5	7.9	8.2	6.3
Mining and metallurgical	0.7	2.1	2.1	3.8	9.3	12.0	8.3	9.6	7.0	8.8	8.4	11.2

[a] Including those on direct relief and work relief.

TABLE 2 PER CENT OF ENGINEERS IN EACH PROFESSIONAL CLASS UNEMPLOYED[a] ON DEC. 31, 1929, 1932, AND 1934, BY AGE OR YEAR OF GRADUATION

		Per cent unemployed on Dec. 31				
Approximate age in 1934	Year of graduation	Chemical, ceramic	Civil, agricultural, architectural	Electrical	Mechanical, industrial	Mining, metallurgical
		1929				
53 and over	Prior to 1905	0.7	1.7	2.2	1.8	3.6
43-52	1905-1914	0.5	0.9	0.3	0.6	2.2
33-42	1915-1924	0.5	0.4	0.3	0.2	1.3
28-32	1925-1929	0.3	0.3	0.4	0.6	0.5
25-27	1930-1932	0.0	0.0	0.0	0.0	0.0
23 and 24	1933-1934	0.0	0.0	0.0	0.0	0.0
		1932				
53 and over	Prior to 1905	3.9	11.2	10.0	11.3	12.8
43-52	1905-1914	7.0	8.8	7.1	9.6	9.6
33-42	1915-1924	5.0	8.9	6.6	8.7	6.0
28-32	1925-1929	8.8	10.2	9.9	11.9	12.4
25-27	1930-1932	15.8	14.7	20.2	15.6	17.5
23 and 24	1933-1934	0.0	0.0	0.0	0.0	0.0
		1934				
53 and over	Prior to 1905	5.9	12.3	11.4	10.2	14.2
43-52	1905-1914	4.1	9.0	7.3	7.7	7.5
33-42	1915-1924	4.4	8.9	5.5	6.0	6.2
28-32	1925-1929	5.5	9.2	5.3	6.0	7.5
25-27	1930-1932	4.9	11.5	6.9	5.8	6.1
23 and 24	1933-1934	11.9	18.0	14.6	10.4	10.7

[a] Including those on direct relief and work relief.

TABLE 3 PERCENTAGE DISTRIBUTION, BY AGE AND TYPE OF EDUCATION, OF ALL ENGINEERS REPORTING A PERIOD OF (GROSS[a]) UNEMPLOYMENT, 1930–1934

	Age in 1934	College graduates, per cent reporting unemployment
All graduating classes		37.8
Entered profession in 1930–1934		
Graduated in		
1933–1934	23–24	47.1
1930–1932	25–27	53.5
Entered profession in 1929 or earlier		
Graduated in		
1925–1929	28–32	36.0
1915–1924	33–42	27.1
1905–1914	43–45	23.8
Prior to 1905	53+	23.5

		Other engineers with	
		College course incomplete	Noncollege technical course
	Age in 1934	Per cent reporting unemployment	
All years		35.4	35.6
Entered profession in 1930–1934			
Born in			
1910–1914	20–24	47.9	48.2
1905–1909	25–29	49.5	49.8
Entered profession in 1929 or earlier			
Born in			
1900–1904	30–34	39.0	41.4
1895–1899	35–39	33.4	34.1
Prior to 1895	40+	30.4	32.3

[a] Includes periods both of direct relief and work relief.

complete a college course and for engineers with a noncollegiate technical-school training.[3] This slightly lower incidence of unemployment for the "other" engineers is explicable on two grounds: (*a*) As a statistical "freak," arising out of slight differences in the age distribution of graduates and "other" engineers, and (*b*) the longer experience record of "other" engineers, for the graduate sample is especially heavily weighted by newcomers to the profession during the depression period 1930–1934. For each particular age group shown in the table, the percentage of unemployment is slightly higher.

From this table, unemployment was greatest among the newcomers to the profession and decreased with the age of the engineer. In all professional groups, there appeared to be an age beyond which the risk of unemployment was apparently common. That age varies among the several professional classes. For civil engineers, it was 43 years, whereas for electrical, and mechanical and industrial engineers, it occurs after 33 years of age.[4]

"Gross unemployment" is used to cover periods of work relief or periods without work of any kind. The figures show the median periods of unemployment.[5]

Table 4 shows the median periods of unemployment, by age, education, and professional classes, in the 5-year period. In connection with the age classifications shown, the period of exposure to the possibility of unemployment should be remembered. Thus, engineers being graduated from college in 1933 had the maximum exposure of 18 months to the hazard of unemployment, and those being graduated in 1934 the maximum exposure of 6 months, before Dec. 31, 1934, the close of the period studied. On the other hand, all four groups of engineers who were graduated prior to 1929 were exposed to the possibility of depression unemployment for the full period of 5 years.

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[3] The table does not show the percentage of unemployment among engineers with only a secondary-school education, for their number was too small to warrant classification by age. The percentage of unemployment among all such engineers was 22.6.

[4] These are the ages as of the end of the 5-year period, 1930–1934.

[5] In other words, the middle point, half of the engineers having had a longer period and half a shorter period of unemployment.

Significant differences in the period of unemployment between the various age groups and between engineers with different types of educational background are noted. Real differences between the several classes of engineer exist, but professional class had a less marked influence on the average period of unemployment than either age or educational background.

For the country as a whole, as indicated in Table 4, the median period of unemployment for engineers who were college graduates was 11.4 months. For engineers who did not complete their college course, it was 16.3 months and for those with a noncollegiate technical-school education, it was 17.3 months.[6] The influence of educational background appears to be persistent whether the data are classified for each of the professional classes or for all engineers combined. However, the difference of almost 5 months in the median period shown in Table 4 as between all college graduates without regard to age and all those whose college course was incomplete exaggerates the spread. Possibly, this spread was absent in the case of the older engineers; the impossibility of making identical age groupings prevents any other conclusion than that, in the case of older engineers, educational background is no longer a determining factor.

In general, the average period of unemployment for graduate engineers tended to increase from about 1 year in the case of those who were graduated between 1925–1929 to almost 2 years for those who were graduated prior to 1905. The older engineer suffered from unemployment because of its greater length when it occurred rather than because of its greater frequency. Although the proportion of those who became unemployed over the 5-year period was only two thirds as great in the case of the oldest group as it was in the case of the youngest group to enter the profession prior to 1930, when unemployment did occur, it tended to last twice as long in the case of the older engineer.

In the majority of cases, engineers survived their periods of unemployment from 1930 to 1934 without public assistance. This was especially true of those who entered the profession prior to 1930.

The first data to be considered are with reference to direct relief. Fewer than 1 per cent of the engineers reported themselves to have been unemployed on Dec. 31, 1929. At that time, no work-relief projects had been inaugurated, and none of the engineers reported themselves as on direct relief.[7] Nearly 11 per cent of all engineers reported themselves as unemployed on Dec. 31, 1932; 31 engineers reported themselves as on direct relief—less than 0.1 per cent of all the engineers and only 0.5 per cent of the number reporting unemployment.

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[6] No figure is shown in the table for engineers with a secondary-school education, for its significance is not certain. The median period for such engineers was 12.4 months.

[7] In this survey, work relief is defined as emergency employment, usually made available on the basis of need, by such agencies as CWA, FERA, and WPA. It does not include engineering work on PWA projects, which should have been reported either as a form of private employment or as government employment for those engineers working in the Public Works Administration itself. Also it does not include engineers hired for strictly administrative work by the various relief administrations. Some overreporting of work relief and a corresponding underreporting of public employment were found. Direct relief refers to direct financial or other assistance from any public authority.

TABLE 4 MEDIAN PERIOD OF GROSS UNEMPLOYMENT,[a] BY AGE, TYPE OF EDUCATION, AND PROFESSIONAL CLASS, 1930 TO 1934

		Period of gross unemployment, in months, of graduate engineers					
Graduating class	Age in 1934	All classes	Chemical and ceramic	Civil, agricultural, and architectural	Electrical	Mechanical and industrial	Mining and metallurgical
All graduating classes		11.4	9.4	11.8	11.5	11.1	12.3
Entered profession in 1930–1934							
Graduated in							
1933–1934	23–24	7.5	7.0	7.9	7.7	7.1	6.0
1930–1932	25–27	11.9	10.6	11.9	13.2	11.1	11.9
Entered profession in 1929 or earlier							
Graduated in							
1925–1929	28–32	12.1	11.1	12.2	12.4	12.0	11.7
1915–1924	33–42	13.4		12.9	14.1	15.2	
1905–1914	43–52	17.8	11.4	17.0	20.7	18.5	17.4
Prior to 1905	53+	23.1		22.9	25.3	22.2	

		Other engineers			
		College course incomplete			
Year of birth	Age in 1934	All classes	Civil, agricultural, and architectural	Mechanical and others	Noncollegiate technical course
All ages		16.3	15.8	16.9	17.3
Entered profession in 1930–1934					
Born in					
1910–1914	20–24	12.5	13.8	11.4	15.0
1905–1909	25–29	14.0	13.9	14.3	15.3
Entered profession in 1929 or earlier					
Born in					
1900–1904	30–34	14.2	13.2	15.1	16.0
1895–1899	35–39	14.6	14.1	15.3	14.7
Prior to 1895	40+	19.4	18.3	22.0	19.2

[a] Includes periods both of direct relief and work relief.

For the 5-year period as a whole, receipt of some direct relief was reported by 0.8 per cent of all engineers with college degrees and about 2 per cent of those who attended noncollegiate technical schools or who did not complete their college course.[8]

ENGINEERS AND WORK RELIEF

Engineer's training was required in the administration of many of the projects designed to benefit other groups in the community. A large increase in nonrelief forms of public employment also occurred. Despite the increase in public employment, work-relief projects were the main source of assistance to those who were unemployed. On Dec. 31, 1932, when nearly 11 per cent of the engineers were unemployed, only 0.7 per cent were on work relief. Two years later, 4 per cent of all engineers were on work relief, which was approximately half of the total number of engineers unemployed at that time. Work relief was slightly more common among engineers without college degrees than among college graduates.

Comparison of the proportions receiving work relief at the close of 1932 and 1934 indicates that the older engineers were favored prior to 1932, while the more recent graduates were being favored in 1934. In 1932, the group that was graduated in the period 1930–1932 had a larger proportion of its membership unemployed than any of the other age classes, but the proportion on work relief, 0.6 per cent, was slightly less in December, 1932, than the proportion among the older engineers, 0.8 per cent of those who were graduated from 1915–1929 and 0.7 per cent of those who were graduated prior to 1915. By Dec. 31, 1934, this situation had been reversed and the proportion on work relief was larger among the recent college graduates than among those who had entered the profession prior to the depression.

Thus far, the discussion of work relief has been confined to the reports for specific dates. For the 5-year period as a whole, a larger number of engineers had some experience with work relief. For all types of engineer, irrespective of background, about one eighth reported some period of work relief, but very wide differences were shown in the extent of work relief for civil engineers and for other types of engineer. Thus, among engineers with an incomplete college course, 19.6 per cent of the civil-engineering group reported some work relief, whereas only 7.5 per cent of those in the other professions considered together so reported.

In all professional classes, age was an important factor in the frequency of work relief. Table 5 gives, for the three professional classes of civil, electrical, and mechanical engineers,[9] the percentages of those receiving work relief, at any time in the 5 years, 1930–1934, classified by age. The figures relate only to college graduates.

TABLE 5 PER CENT OF GRADUATE ENGINEERS, BY YEAR OF GRADUATION AND PROFESSIONAL CLASS, REPORTING WORK RELIEF AT ANY TIME, 1930–1934

	Per cent reporting work relief		
Year of graduation	Civil engineers	Electrical engineers	Mechanical engineers
All years	18.3	9.3	8.7
1933–1934	26.4	12.5	10.2
1930–1932	25.2	12.8	10.4
1915–1929	15.9	6.2	7.4
Prior to 1915	12.4	6.3	7.6

The median period of work relief was approximately 5 months, as shown in Table 6 for college graduates classified by year of graduation in the three professional groups of civil, electrical, and mechanical engineering.

TABLE 6 MEDIAN PERIOD OF WORK RELIEF AMONG GRADUATE ENGINEERS, 1930–1934, BY YEAR OF GRADUATION AND PROFESSIONAL CLASS

	Median period of work relief, months		
Year of graduation	Civil engineers	Electrical engineers	Mechanical engineers
All classes	5.0	4.4	4.9
1933–1934	4.1	3.8	4.1
1930–1932	4.8	4.3	4.5
1915–1929	5.6	4.6	5.7
Prior to 1915	5.5	6.5	5.6

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[8] In New York City, direct relief appears to have been more extensive through the Professional Engineers' Committee on Unemployment than through public agencies.

[9] The civil engineers here tabulated do not include architectural and agricultural engineers, nor do the mechanical engineers include industrial.

Working of Nickel-Base Alloys

(Continued from page 177)

Riveting is not recommended because of the tendency of rivets to work harden and lose ductility. Welded joints are preferable and have been found to be best by experience.

MACHINING AND WELDING ILLIUM

As with other metals, the machining of Illium is not difficult so long as the proper procedure is used. The most satisfactory cutting speed for turning is from 20 to 25 fpm, using a feed of $^1/_{32}$ in. per revolution for roughing. Roughing tools should be ground with a straight cutting edge across the entire width of the tool which should be set at an angle of 45 deg. Finishing tools should be ground to a V-shape with a nose radius of $^1/_{32}$ in. Both roughing and finishing tools should be ground with a rake similar to that used for turning hard steel and the nose clearance should not be more than 4 deg. E.V.M. tool bits available from the Vanadium Alloy Steel Corporation, are recommended.

High-speed-steel milling-cutters ground with minimum clearance should be used. Cutting speeds should be from 20 to 25 fpm, using a medium feed.

High-speed drills are recommended, and these should be as short as the job will permit. The cutting edges should be ground as for drilling tool steel. Drilling should be completed without interruption, and the feed should be slow.

The use of a good grade of cutting lubricant is recommended for cutting-off, milling, and drilling operations. For tapping or threading, Houghton's Frapol No. 414 is recommended.

When polished, Illium takes a high luster. After the finishing cut, a spotted appearance may sometimes be noted. This can be eliminated by roughing down with No. 40 emery cloth followed by treatment with oil and Nos. 80 and 120 emery cloth.

Illium welds readily, both to itself and to other metals. When Illium welding rod is used, the structure of the weld is practically identical with that of the original casting. Uncoated rod should be used for acetylene welding and a slightly reducing flame avoids porosity of the weld. A coated rod should be used for arc welding, and the polarity should be reversed.

These notes on the working of high-nickel alloys were compiled from data supplied by the Haynes Stellite, Burgess-Parr, and International Nickel companies, producers of the various materials discussed.

MASSACHUSETTS— A DECLINING STATE?

By W. RUPERT MACLAURIN

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PROF. D. H. DAVENPORT and J. J. Croston have recently published an interesting study on "Unemployment and Prospects for Reemployment in Massachusetts."[1] The authors point out that Massachusetts presents a unique situation for the study of unemployment, as there exist for that state comprehensive data on unemployment taken in two of the depression years, 1930 and 1934. While unemployment figures for 1930 are available for every state in the union in the regular Federal Decennial Census of the population, the figures for 1934 were obtained by a special census of unemployment in Massachusetts. This was a relief project made possible through funds granted by the CWA and FERA.[2] It had been originally intended to undertake a similar census in other states, but the task was expensive and only the Massachusetts census was actually undertaken.

The severity of the unemployment situation in Massachusetts is indicated by the fact that as of January 2, 1934, 24.9 per cent of employable persons in Massachusetts were wholly unemployed, and 9.6 per cent employed only part time. Of the wholly unemployed, 61 per cent had had no employment for a year or more, 42 per cent had been unemployed for two years or more, 23 per cent for three years or more, and 10 per cent for four years or more. On the basis of these figures Professor Davenport and Mr. Croston estimated that there had been lost in the State of Massachusetts between January, 1930, and January, 1934, more than ten million man-months of labor; equivalent, they believed, to a loss of about $800,000,000 in purchasing power.

HEADS OF FAMILIES FAVORED

In studying the incidence of unemployment in the depression the authors found that there had been considerable discrimination on the part of employers in favor of retaining heads of families. Thus, in 1934, of the heads of households, 26.9 per cent were unemployed, while 43.8 per cent of those who were not heads of households were out of regular employment. It would be interesting to know how general this practice has been in other states, and to what extent employers obtain full information in regard to the earning status of other members of the household. If, for example, a policy of blanket discrimination in favor of heads of households were followed, this might not always be justified, especially where all the other members of the family were employed as well.

Government relief-work agencies also followed the policy of favoring heads of households. Thus, in 1934, 22.3 per cent of the heads of households were temporarily at work on government projects, while only 11.6 per cent of those who were not heads of households were working on such projects.

The incidence of unemployment in Massachusetts appears to have fallen particularly heavily on the negro. There were about 21,000 gainful workers in Massachusetts classified as black in 1934, against 1,785,000 classified as white; 39.1 per cent of the employable negroes were unemployed as compared with 24.8 per cent for the whites. This does not necessarily indicate racial prejudice. One would naturally expect that in a period when skilled workers were constantly being forced to find employment further and further down the wage scale, the less skilled workers at the bottom of the ladder would suffer most, because they would be displaced by workers who, in better times, would not compete with them.

LOSS OF WORKERS AND UNEMPLOYMENT SERIOUS FACTORS

The authors point out that unemployment in Massachusetts has been aggravated by the downward trend in manufacturing from 1920 to 1930. During this decade Massachusetts showed a net loss by migration of about 125,000 persons. The majority of these went to the industrial states of New York, Connecticut, New Jersey, Michigan, and Rhode Island. In these states industrial employment was expanding, while in Massachusetts it was contracting. It appears, therefore, that most of these persons were attracted by better occupational opportunities than they found at home. The authors found, furthermore, that the population in Massachusetts in 1934 was showing a current rate of growth substantially lower than that of other large states. Massachusetts also showed a tendency toward an older average age. This was probably the result of the migration of younger workers.

The loss of workers in mechanical and manufacturing occupations was offset by an increase in the other classes of occupations. The change in the occupational classification of workers between 1920 and 1930 is shown in Table 1.

TABLE 1 GAINFUL WORKERS IN MASSACHUSETTS BY MAJOR OCCUPATIONAL CLASSES: 1920 AND 1930

	—Percentage—	
Occupational classifications	1920	1930
Manufacturing and mechanical industries	58	48
Service industries	26	32
Trade industries	13	16
Extractive industries	3	4
Total	100	100

Professor Davenport and Mr. Croston, however, are pessimistic about further expansion of the service and trade industries in the face of the continued decline in manufacturing.

The major portion of their study is devoted to a detailed discussion of the incidence of unemployment and the prospects of reemployment in the different manufacturing industries in Massachusetts. These are classified according to number of wage earners employed in 1929. The first four groups listed in order of importance, i.e., leather goods, cotton goods, iron and steel products, and woolen goods, account for nearly 47 per cent of the total wage earners. For all of these groups except woolen goods, the authors conclude that the downward trend in Massachusetts is continuing, and that it seems unlikely in the next few years that the unemployed workers will find employment again in their former trades in the Commonwealth.

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[1] "Unemployment and Prospects for Reemployment in Massachusetts, With Particular Reference to Manufacturing Industries," by Donald H. Davenport and John J. Croston. Bureau of Business Research, Graduate School of Business Administration, Harvard University, Boston, 1936, pp. 73. $1.00.

[2] Report on the Census of Unemployment in Massachusetts as of January 2, 1934. Department of Labor and Industries, Boston, 1935.

One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Of the remaining industries in Massachusetts taken in the aggregate, little hope is expressed that they will be able to absorb all their own unemployed in the next few years.

The authors find that over 75 per cent of the wage earners employed in "manufacturing" in 1929 were in industries which showed definite downward trends. Of the subdivisions of the industrial groups in which Massachusetts showed growth from 1919 to 1929 there was only one, "jewelry, clocks, watches, and silverware," in which the rate of growth appeared to be as great as it was for the country as a whole. This group accounted for only 1.8 per cent of the employment in manufacturing in Massachusetts in 1929.

The authors conclude their monograph in a pessimistic vein. "Further growth in the summer resort and tourist business and continued expansion in the management and financial services, quite possibly in the educational services, may reasonably be expected. But all these possibilities still leave on the manufacturing industries the chief burden of absorbing the unemployed during the next few years . . . . All we can say is that the trends brought to light in this investigation make it appear unlikely that the existing manufacturing industries in Massachusetts will be able in the near future to reabsorb their own unemployed."

. . . .

"If the state faces the prospect of exporting its surplus man power, it must realize that emigration will tend to increase still further the proportion of the old people among those who remain. . . .

"Lest Massachusetts view too complacently the prospect of allowing its problem of unemployment to be solved through the migration of surplus workers to other states, the State should contemplate the cost this involves. . . . Real property values depend upon population. Increasing values result from a growing population. Property values form the basis of the tax system. . . . If population declines, however, the tax base is reduced, with the result that the tax rate rises. Delinquencies increase. The property owner is caught between the reduction in value and in rents, on the one hand, and the increase in tax rates on the other. To the extent that increasing taxes must be borne by industries, an addition to their burdens is made and this addition tends to make the prospect of location beyond the borders of the state seem more advantageous by contrast."

Of the downward secular trend of employment in Massachusetts, the authors conclude in part, "this reflects the more or less normal shifting of industry in response to changes in markets, in raw materials, in natural resources, in manufacturing technology, and in types of labor required. But this is not all; Massachusetts. . . . has in many respects deliberately taken a position on such high ground in matters of taxation and labor legislation that numerous industrial navigators have perforce had to seek other waters to keep their craft from going aground."

The authors express no opinion as to how much of the unemployment is a reflection of the natural shift of industry away from the New England area, and how much the result of adverse taxation and labor legislation. It would be instructive to have additional studies made of this particular point. The allegation that Massachusetts taxation and labor legislation has handicapped industry is not a new one. Employers have repeatedly complained in the past that they were adversely discriminated against in Massachusetts. In 1931 the engineering firm of Freeland, Bates, and Lawrence in a study prepared for the Massachusetts Industrial Commission, concluded that "Massachusetts has pioneered in legislation until its pioneering has created a burden which industry is finding it difficult to absorb and retain a competitive position with outside industries. The foremost criticism is against the so-called 48-hour law, which law, is in effect in only one other competing industrial state, New York, but in New York this law is flexible and is not comparable with the rigidity of legislation in this State. This law, together with the law which prevents the employment of female labor in textile mills after six o'clock at night, has been given as an important reason for the migration of some of the Massachusetts industries and the difficulty in securing new ones."

". . . We hear it generally expressed that if Massachusetts chooses to pioneer in labor laws which do not affect competing industries in other states, we must expect further loss of industry. . . . Taxes upon industry are considered by many executives equally as important as legislation as an impediment to industrial progress in this state."

The problem is a controversial one which needs further study at the present time. There can be no doubt that Massachusetts has pioneered in labor legislation and that the legislation on the statute books has been enforced more rigidly than in many other states. However, some of the handicaps complained of by manufacturers have been eliminated recently. Thus in the textile industry, the Commissioner of the Department of Labor and Industries now has the power to suspend the six-o'clock law for women where he considers that conditions warrant it. In the field of taxation, Massachusetts has removed machinery from the general property tax on corporations, which has given substantial relief.

SITUATION CALLS FOR FURTHER REMEDIAL ACTION

There appears to be a gradual tendency, furthermore, for the other states to adopt some of the labor legislation in which Massachusetts has pioneered. None the less, the situation would appear to call for further remedial action. It is unfortunate that the progressive states should suffer in any fashion from the introduction of labor legislation which is socially desirable. The problem illustrates the difficulty of leaving such matters to the states rather than providing for them by federal legislation. The remedy would appear to be either for the federal government to enact such labor legislation as the Supreme Court will permit, or for the states to cooperate more among themselves in providing and in enforcing uniform labor legislation. Such cooperation would not need, however, to be nationwide, but could be confined to the principal industrial states.

So also in the field of taxation, more uniform practices need to be developed. Something should be done in particular to curb the prevalent practice of competitive bidding for industries by tax inducements. There is a great deal of unnecessary social waste and suffering involved through industry's shifting from one section of the country to another on the basis of lower taxes and adverse labor legislation. Organized labor has been short-sighted in the past in pursuing restrictive policies in certain areas which has resulted in driving industry elsewhere. It seems clear that the goal which we should strive for in industry is one in which regional development will depend as far as possible on economic rather than on artificial advantage.

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals

WROTE Doctor Holmes in the *Atlantic Monthly* for November, 1857: "If I were a prince I would hire or buy a private literary teapot, in which I would steep all the leaves of new books that promised well. The infusion would do for me without the vegetable fiber." So, in a modest way, these pages attempt "to draw the virtue out of what is best worth reading as hot water draws the strength of tea leaves." Necessarily, subjects related to engineering are dealt with, although not all sources are engineering publications. Fields of broad general interest are covered for the benefit of busy but inquiring readers.

The Hall of Fantasy

NATHANIEL HAWTHORNE

BRIEF reference in Van Wyck Brooks's "The Flowering of New England" to Hawthorne's "Hall of Fantasy," to the effect that "he ridiculed the god of the machines," recalls that section in "Mosses From an Old Manse" which links mystics with inventors—"another order of dreamers, peculiarly characteristic, too, of the genius of our country."

Here, for example, Hawthorne saw the model of a railroad through the air and a tunnel under the sea; a machine for the distillation of heat from moonshine, another for the condensation of the morning mist into blocks of granite; a lens for making sunshine out of a lady's smile; a scheme for fixing the reflections of objects in a pool of water and one for giving a permanent dye to ladies' dresses in the glorious clouds of sunset. Utopian inventions, he called them; "but after all a more imaginative collection is to be found in the Patent Office at Washington."

Utopian, possibly, for Hawthorne a century ago; but would this be ridicule of the god of machines today? Railroads through the air and tunnels under the sea are common enough. It was the light from Arcturus, to be sure, and not the moon, that opened the Century of Progress Exposition at Chicago a few years back. It was a less perfect reflector than water that Draper used to hold forever a fleeting image in a photograph. From the stored energy of the sun man has made coal-tar dyes. The earth itself is a "condensation" product. And if perhaps no lady's smile has "so irradiated the earth that we have a constant supply for domestic use," an equally fantastic substitute has taken its place in electricity; and who can say but what some engineer-mystic may yet perfect a less cumbersome method?

"The fantasies of one day are the deepest realities of a future one," said Hawthorne. "The white sunshine of actual life is necessary in order to test them. I am rather apt to doubt both men and their reasonings till I meet them in that truthful medium." So are we all. And today science has provided more of that white sunshine than the world has known heretofore.

The Patent Office is being ably assisted today in its rôle of the hall of fantasy, as the abstracts in these pages will prove.

Fires and Research

JOURNAL OF THE FRANKLIN INSTITUTE

FROM a paper on "Some Problems of the National Bureau of Standards," by Director Lyman J. Briggs, in the January, 1937, issue of the *Journal of the Franklin Institute*, the following excerpt emphasizes the importance of research of the type carried on by the Bureau:

Studies are being made of the fire resistance of different types of structures. Slow-burning construction is a great advantage in homes and other buildings where fireproof construction is not feasible, because it provides time to fight the fire. Slow-burning partitions are now under investigation at the Bureau, in relation to their use in homes and in passenger ships.

The fire loss of this country amounts to $450,000,000 a year. I wonder if you visualize what this means? It is equivalent to the annual destruction of a row of $10,000 homes on 100-ft lots lining one side of a highway extending from here (Philadelphia) to Chicago. And if you rode the length of this highway of holocaust, you would find in front of the ruins of one home in every five a white cross telling its mute story of the loss of a life from fire. If painstaking laboratory fire tests point the way to the reduction of this appalling loss of life and property, is any undertaking more worthy of support?

The world hears little about the bridges that do not fail or the ships that are not lost at sea or the skyscrapers that do not fall down. The painstaking research that made them possible is taken for granted. This is not news. But when bridges and ships and airplanes and dirigibles are made bigger and bigger without simultaneously making them better and better, then comes news, stark news—a failure, a tragedy, and an investigation. When shall we learn that engineering research must not only keep abreast but ahead of engineering development if these failures, these tragedies, are to be avoided? When shall we learn that engineering research should be generously supported because it pays—pays richly in things that do not happen?

Predicting Flood Stages

CIVIL ENGINEERING

HOW engineers use the accumulated experiences of past floods in the Mississippi River Valley to predict the height of flood waters at certain points with the aid of stage-relation diagrams is described in the February, 1937, issue of *Civil Engineering* by E. W. Lane, in an article entitled "Predicting Stages for the Lower Mississippi."

On a stage-relation diagram for a section of the river into which no important tributaries empty, the stage at a given location below a gaging station is determined from the reading of the gage at the upper station. A single straight line on the diagram is necessary for each location below the upstream gaging station. The time at which this stage is reached is predicted from other curves showing time of travel from the upper gaging station, and these curves are naturally affected by height of stage and distance between the stations.

Where tributaries are involved, as at Cairo, for example, multiple-line stage-relation diagrams are necessary, as illustrated by Fig. 1. Here, as Mr. Lane says, to find the Cairo stage produced by any given stages at Paducah and Cape Girardeau, follow across to the right along the line representing the height on the Paducah gage to the height in the diagonal-line system representing the Cape Girardeau gage and thence downward to the bottom scale, which will give the height of the Cairo gage the next day.

Crevasses, spillway action, and cutoffs affect the actual flood stage and hence, where these become factors, the actual and the computed stages will not be the same Fig. 2 shows the effect of a crevasse on the flood stages at Cairo in 1912. Mr. Lane explains how the stage-relation diagram is used to show the effect of crevasses on stages. Adjustments are made to compensate for the lowering of stages resulting from crevasses that affect the heights at the upstream gaging stations, with results such as are shown in the various curves of Fig. 2 for the 1912 flood at Cairo.

Concluding his brief description, Mr. Lane has the following to say about the limitations of the stage-relation method:

A stage-relation diagram gives the mean relation between the stages. It does not take into account the differences due to difference in rates of storage of water in the river itself and in the overflow areas as the surface rises or falls, but gives results for ordinary conditions. Floods which rise more rapidly than usual at the upper station produce a greater rate of storage and therefore smaller flows and peaks at downstream stations. The reverse is true for slowly rising floods.

Since stage-relation methods take no account of variations in storage rate, they are more accurate where the storage capacity is small. For this reason the best results were secured near Cairo and in the reach below Angola, and less satisfactory results were obtained in the backwater basins. It is believed that further study to analyze the effect of different storage rates would develop corrections for the stage-relation method which would make close estimates possible.

Those who take the trouble to read the complete article by Mr. Lane in *Civil Engineering* will find in the same issue two other flood items of general interest. In a biographical sketch of James Bickens Francis, past-president of the American Society of Civil Engineers, is brief mention of an emergency canal gate, termed by the people of Lowell as "Francis' folly" at the time it was built in 1848, which has twice since then saved the city from the worst effects of flood waters. Less than a year ago this long unused gate was closed and held the water although it reached a height of 26 ft above the sill. The other item is the announcement that the March issue of the *Proceedings* of the A.S.C.E. will be given over to the eight papers comprising a symposium on flood control that were a feature of the Society's Pittsburgh meeting last fall.

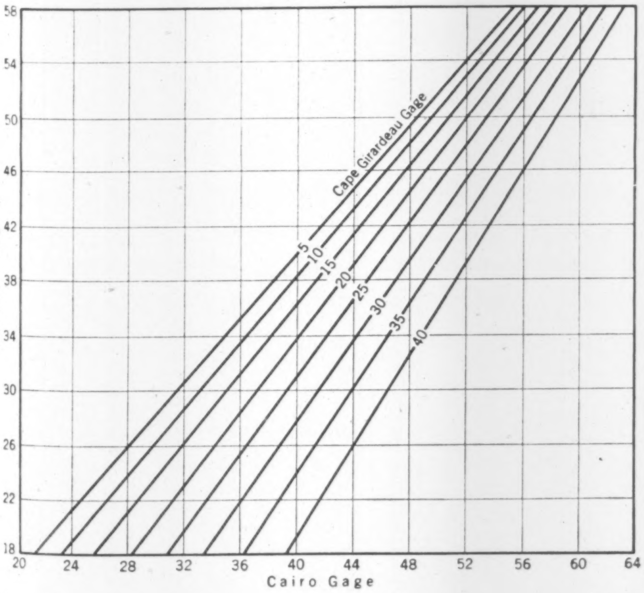

FIG. 1 CAPE GIRARDEAU-PADUCAH-CAIRO STAGE RELATIONS

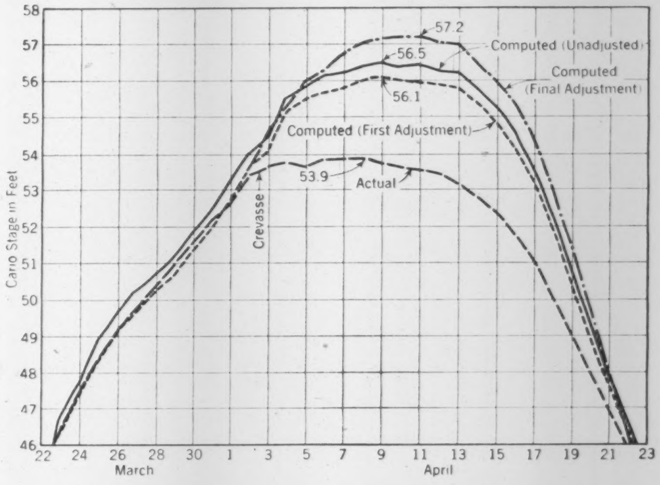

FIG. 2 STAGES AT CAIRO DURING THE 1912 FLOOD, SHOWING EFFECT OF CREVASSE

Bacteria in Air Conditioning

INDUSTRIAL AND ENGINEERING CHEMISTRY

Bacterial control in air conditioning is the subject of a paper by T. S. Carswell, J. A. Doubly, and H. K. Nason in the January, 1937, issue of *Industrial and Engineering Chemistry*. The authors point out that modern air-washing and recirculating systems offer an excellent opportunity for bacterial purification of the air as well as purification in respect to dusts and pollens.

It is frequently assumed, they say, that the water scrubbing to which the air is subjected in the average humidifier will effect the removal of bacteria, as well as dusts, pollens, and molds, with a high degree of efficiency. Actually, however, there is much evidence to the contrary. They therefore report an experimental study made by them, and describe the use of a germicide used in air washing water, a technique which, they say, has many advantages from the standpoint of cost and convenience.

Most of the common antiseptics, such as chlorine, chloramine, phenol, cresols, and the chlorinated phenols, cannot be used because of the odor imparted to the air. Since the amount of air in contact with the water is relatively enormous, a substance of distinctive odor may seriously taint the air, even though its vapor pressure is quite low. Mercurials and copper salts cannot be used since they are extremely corrosive to the metals which make up the equipment. Ammonium salts and amines cause corrosion of copper and brass parts.

The ideal germicide for bacterial control in air conditioning should be highly toxic to the organisms involved, noncorrosive to the metals usually used in engineering equipment, odorless when used in effective concentration, nonvolatile, nontoxic to man and to higher animals, economical and safe to use, stable even on prolonged aeration, and easily dissolved in water. A commercial mixture of the *o*- and *p*-benzyl phenols meets these requirements and was therefore selected. These benzyl phenols are not only effective in high dilution against many types of bacteria but have the added advantage of being particularly toxic to algae and protozoa, and hence are well adapted to slime control.

In reporting their conclusions the authors say that the results seem to show that germicides of the benzyl phenol type offer a cheap and convenient way to improve the efficiency of air-washing equipment in respect to bacterial removal. Only the physical measurements of bacterial reduction are reported, and no conclusion as to its possible hygienic significance can be made or inferred. In fact, the industrial application of germicides for the elimination of mold and bacteria from air circulated for process work, such as in bakeries, breweries, and other fermentation industries, offers interesting possibilities entirely independent of the health aspect.

Aircraft Diesel Engines

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

THE 1936 annual report of the National Advisory Committee for Aeronautics contains a section on compression-ignition engines from which the following comments are summarized: The rapid development of the compression-ignition, or Diesel-type, engine for use in all forms of automotive equipment has not been followed in this country by the development of a successful Diesel aircraft engine. The low fuel consumption and reduction in fire hazard obtained by the use of the compression-ignition engine should be of particular interest to operators of long-range transport aircraft. The research work of the Committee on the compression-ignition engine has been continued with the object of obtaining fundamental knowledge concerning the fuel-injection and combustion processes and of increasing the specific power output. A form of integral combustion chamber in which high-velocity air flow is utilized for distributing and mixing the fuel and the combustion air is being investigated. The specific power output obtained with a single-cylinder liquid-cooled engine using this combustion chamber compares favorably with the maximum obtained from present supercharged spark-ignition aircraft engines.

A constant-volume bomb has been used to investigate the effect of air temperature and density on the autoignition and subsequent combustion of Diesel fuel. The bomb is mounted in an electric furnace and can be heated to a maximum temperature of 1100 F; the density of the air in the bomb can be adjusted to any desired value. The minimum ignition lag obtained with this apparatus, the fuel being injected as in the compression-ignition engine, is 0.001 sec. The amounts of ignition lag and combustion time obtained with the bomb are comparable with those obtained in the compression-ignition engine.

A research has been completed to determine the effect of increasing the degree of atomization of the fuel injected into a prechamber compression-ignition engine with forced air flow. The degree of atomization of the fuel was varied by increasing the fuel-injection pressure from 4000 to 9000 lb per sq in. The results showed that the ignition lag decreased 35 per cent and the brake mean effective pressure increased 19 per cent with increase in the fuel-injection pressure.

An investigation has been completed on the rates of discharge from a single-cylinder fuel-injection pump connected to two injection valves.

With a single-cylinder engine having a displacer piston and a combustion chamber of vertical disk form, a brake mean effective pressure of 200 lb per sq in. with a specific fuel consumption of 0.46 lb per bhp-hr was obtained at 2000 rpm and boost pressures up to 10 lb per sq in.

Internal Centerless Grinding

MACHINERY (NEW YORK)

RAPID advance in internal centerless grinding, a machine-shop technique said to be now in its third year, is reported by D. C. Page in the December issue of *Machinery*. General description is given of the internal grinding of such parts as the races of ball and roller bearings, straight holes as large as 8 in. in diameter, single- and double-tapered holes, bores closed at one end, and those with tapered and shouldered outside surfaces.

In grinding bores by the centerless method a previously ground outside cylindrical surface on the work is utilized for holding and rotating the work in proper relation to the grinding wheel. This is said to insure concentricity of the bore with finished outside surface and also uniform wall thickness.

In general the part is located and supported in the machine by a large roll on one side and two smaller rolls on the opposite side. The work is driven by the large or "regulating" roll which also prevents the work from attaining too high a speed due to its contact with the grinding wheel. The upper of the two smaller rolls holds the work in contact with the regulating roll and the lower serves as a support. In the grinding of small pieces a narrow blade is used instead of a roll for support.

Examples are given of sleeves for airplane-engine cylinders, ground internally to specified diameter with plus 0.0010 in. and minus 0.0000 in. concentric within 0.0002 in. for their entire length; valve-seat inserts for automobile-engine cylinder blocks ground on the beveled seat; roller-bearing races with tapered surface and two shoulders on the outside, ground internally; roll bushings as small as 0.5512 in. outside diameter ground internally to 0.3574 in. diameter; and a universal-joint bushing, $1^1/_{16}$ in. outside diameter, in which a blind hole, closed at one end, is internally finish-ground to a diameter of 0.847 in. for a length of $^{15}/_{16}$ in. at the rate of 160 pieces per hour.

Machine-Tool Developments

MACHINERY (LONDON)

TWENTY-TWO pages of the December 10th issue of *Machinery* (London) are devoted to a review of improvements in design and trends in practice in the machine-tool fields in Great Britain and America, and on the Continent during 1936. In the same issue an editorial calls attention to the sudden demand placed on the British machine-tool industry as a result of recent activity, primarily in connection with the rearmament program. This characteristic feast or famine condition in the industry, as has been noted by W. H. Rastall in MECHANICAL

ENGINEERING in the past as also obtaining in this country, is attributed to the shortsighted practice of manufacturers in buying new machine tools only to increase capacity during periods of heavy demand and to the policy of the government in respect to depreciation and obsolescence allowances.

Introducing the more detailed reports on features of British, American, and Continental machine-tool practice is a general summary which reads as follows:

The past year has not been signalized by any outstanding developments in the machine-tool field, mainly owing to the high pressure of production experienced during the period.

Progressive firms have, however, consistently developed their designs on lines which take care of one or more of three fundamental requirements, namely, increased production capacity, a higher degree of accuracy in the work produced, and greater efficiency as regards running costs and maintenance.

Cutting times have been reduced by designing the machines to accommodate super-high-speed steel and cemented-carbide tools, while grinding machines are suitable for plunge-cut methods or heavier feeds. Antifriction bearings are used almost exclusively; but when, as on certain machines, the cutter or work spindles are supported in plain bearings, special lubrication systems are provided.

Moreover, machines are now more rigid, individual components and the complete assembly having been strengthened. The elimination of vibration has been further assured by modifying the driving arrangements and removing most of the gearing from the headstock. Variable-speed motors and the various new mechanical and hydraulic steplessly variable transmission units have helped in the reduction of cutting times by facilitating the setting of the machine to run at the most suitable speed. To enable direct-current motors to be used where only alternating-current supply is available, greater use is being made of hot-cathode rectifiers.

As the time required for the cut has been reduced, so the time occupied by loading and the nonproductive movements of the machine and the operator have assumed greater importance. Loading has been simplified by the provision of electrically, hydraulically, or pneumatically operated chucking devices, while the developments in electrical, single-lever, and color control systems have led to reduced idle times. Grouped controls also facilitate the operation of the machines, and it is in this connection that independent motor drive for the main spindles and traverse movements has proved extremely valuable, remote control from pendant or fixed push-button stations being employed. The new variable-speed transmission systems are particularly well adapted to single-lever or handwheel control.

The use of stronger component parts, special semisteel castings, chilled, or hardened and ground guideways, precision antifriction bearings, and pressure lubrication systems, all make for increased accuracy of the machine and the work produced, and for the maintenance of this accuracy.

The application of hydraulic operation to the traverse movements of a large planing machine and the latest developments in unit construction illustrate significant trends in design.

The increased demand for components of fine limits and finish, more especially by motor-car and aero-engine manufacturers, is indicated by the number of high-precision machine tools, such as jig-boring, fine-boring, fine-turning, and thread-grinding machines, which are now available. These machines are equally suitable for machining precision parts in small or large batches.

While broaching methods are being used more extensively for finishing external surfaces, two other machining processes have been developed and applied commercially. The principle of down-cut milling is not new, but it is only recently that the advantages of this method have been appreciated to the extent that special machines operating on this principle have been designed. In addition, a new system employing an enveloping cutter is now being employed successfully for finish-generating the teeth of external and internal spur gears.

Recent developments in die-casting technique are of outstanding importance, for, whereas previously this method could only be used with certain special alloys, the field of application has been extended to include brass and iron. A number of fully automatic die-casting machines have also been introduced.

Owing to the improvements in the design of welding machines, particularly those used for spot welding, the speed of operation has been materially increased. The new oxygen-flame cutting machines having three burners operating simultaneously are capable of a remarkably high output.

Cracking Developments

REFINER AND NATURAL GAS MANUFACTURER

ENGINEERS who wish to bring themselves up to date on what has been going on in the cracking process in the oil industry will turn with interest to the paper on "Cracking and Its Economic Significance," by Gustav Egloff, read at the Division of Refining Session of the American Petroleum Institute last November and published in the December, 1936, issue of *Refiner and Natural Gasoline Manufacturer*. In a convenient summary, here quoted, Mr. Egloff sets forth the principal topics discussed in his paper.

The cracking process conserved 1,227,000,000 barrels of crude oil during 1935, which is based upon the increased yields and high quality of the gasoline.

The capital cost to produce and transport 1,227,000,000 barrels of crude oil would have been $1,500,000,000 had the cracking process not been developed.

Polymer gasoline up to 100 octane rating is being produced from cracked gases. When all the units under design and construction are operating, they will produce at the rate of more than 300,000,000 gallons of gasoline a year, which will represent a yearly conservation of 53,000,000 barrels of crude oil.

Polymer lubricants have high wear resistance in motors; and, when added to lubricants, they show a saving in some cases of 40 per cent of the oil.

It is estimated that there is a $10,000,000 a year chemical business based upon the utilization of antioxidants, dyes, and color stabilizers in motor fuels.

A huge new industry has developed from the use of alloys which permit greater operating efficiencies and, therefore, have an important bearing upon the economics of cracking.

The use of control instruments in cracking units has tended toward more centralized control, thereby increasing length of runs, throughputs, yield, and quality of products.

The manufactured-gas industry has been seriously affected by the vast amount of refinery gases that have supplanted, at least in part, their regular product.

The production of fuel oil, coke, and gas from the cracking process is competitive with about 65 million tons of bituminous coal a year.

A host of chemical products are being produced from the treatment of cracked materials—such as resins, rubber substitutes, ethers, alcohols, glycols, acids, aldehydes, pickling agents, acetylene, and sulphuric acid.

Vast as has been the achievement of cracking and the utilization of its products, one may well say that, with the army of research workers now in the oil industry, new discoveries will follow—with many products yet to come. It may well develop that the researcher will first design the hydrocarbon or hydrocarbons that he desires for the use to which they are to be put, and then find ways of producing them. For example, *isooctane* but a few years ago was a chemical curiosity and was synthesized at a cost of $20 a gallon. Now the industry produces it in commercial quantities for airplane use.

There is no one more alert than the oil industry in striving for full conservation of oil resources and products derived therefrom. It is the oil industry itself that is forcing the conservation ideal by spending huge sums yearly in research to utilize its resources and products to the maximum utility for social and economic benefit.

Novelties in Steam Boilers

THE INSTITUTION OF MECHANICAL ENGINEERS

NOVEL designs of modern steam generators, introduced to readers of MECHANICAL ENGINEERING through such papers as those on the Velox boiler and the Steamotive, must have emphasized the fact that those whose acquaintance with steam power was formed in the days when fire-tube and water-tube boilers offered a convenient classification of a relatively few types need to be brought up to date. With emphasis on German constructions that are more radical than those seen in this country, Friedrich Münzinger discussed "Modern Forms of Water-Tube Boilers for Land and Marine Use" at a meeting on November 20 of The Institution of Mechanical Engineers.

The main causes of change in the construction of water-tube boilers since 1920, he said, are the introduction of pulverized-fuel firing, the astonishing increases in steam pressures and temperatures, the heating of feedwater by bled steam, and the extensive use of chemically treated feedwater.

The amenities of international relations are graciously covered in the statement that practically all industrial nations have contributed to the advance of boiler construction. The United States, said Dr. Münzinger, is above all to be thanked for the construction of practical pulverized-coal-firing systems and for important research into heat transfer. Great Britain is the birthplace of the first boiler with completely water-cooled walls (the Wood boiler) and of the first forced-flow boiler (the Benson boiler); Germany has carried out extensive research into the relationship between heat transfer and loss of draft and has developed forced-flow boilers; and Switzerland has produced the first boiler with a supercharged furnace (the Velox boiler). Then turning to the attitude with which engineers must view all developments in their profession, he observed shrewdly that close specialization and scientific methods of working are of great importance if the utmost in power and efficiency is to be won, but no less valuable are common sense, cool-headedness, and the ability to recognize essentials. These qualities are the finest guard, he asserted, against the degeneration of theory into fruitless, scientifically crabbed speculations, and against overemphasis of theoretical quibbles at the expense of practical engineering.

A number of schematic cross sections of stationary boilers of present design were next offered with observations on stable conditions of water circulation in natural-circulation boilers and the effect of chemically treated feedwater. Directing his attention to forced-flow boilers (Loeffler, La Mont, Velox) in which steam or water pass continuously through the heating surface, Dr. Münzinger differentiated them from once-through boilers (Benson and Sulzer) in which exactly as much water is forced through the heating surface as is converted into steam. With the aid of diagrams in some cases he discussed forced-flow boilers in relation to their behavior when fed with impure feedwater, the power required by feed and circulating pumps, behavior under changes of load, and cost, and concluded by saying that, in general, forced-flow boilers are primarily to be considered for special purposes, and that the question of first costs renders it rather unlikely that they will displace the natural-circulation boiler to any great extent within the near future, since the latter type adequately fulfills the exacting requirements of today and has been brought by decades of experience to a high degree of perfection.

A following section discussed special boilers for fluid and gaseous fuels and the advantages of heavily loaded furnaces. The final section was devoted to water-tube marine boilers, with cross sections of the Yarrow (*Queen Mary*), Johnson, Loeffler, and Sulzer (single-tube) boilers and a table of principal proportions of 15 installations of typical merchant ships.

Looking to the future, Doctor Münzinger said that if it is possible to make large boilers as reliable as those of usual capacities, the safety and ease of maneuvering of multiscrew ships can be much enhanced by dividing the whole machine plant into several fully automatic units, each consisting of a turbine with either one or two automatically regulated boilers and installed in a separate watertight compartment.

Flow of Boiling Water

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

LAST August M. C. Stuart and D. Robert Yarnall presented a paper in MECHANICAL ENGINEERING on fluid flow through two orifices in series. Another analysis, related to the flow of boiling water through orifices and pipes, has recently been made by W. T. Bottomley in a paper read before the North-East Coast Institution of Engineers and Shipbuilders at a meeting in Newcastle-on-Tyne, Dec. 4, 1936.

In this paper the theory of the flow of boiling water through orifices at constant entropy is developed on orthodox lines, taking into account the effect of initial static head of water before the orifice. It is shown that when the initial static head is less than a certain value depending on the initial pressure vaporization occurs before the throat of the orifice. For higher initial static heads vaporization commences at the throat. The characteristics of the flow under these conditions are different. Actual tests carried out on orifices show that the coefficient of discharge can be several times greater than unity due to the effect of surface tension which lowers the pressure at which vaporization takes place. The condition of flow at the throat is that of unstable equilibrium. Due to the surface tension the orifice is self-regulating over a large range of flow for a given initial pressure and is a satisfactory substitute for ball-float traps.

The theory of the flow through pipes is developed and its application to the pipe on the discharge side of orifices; and it is shown that since the pressure at the throat of the orifice is considerably less than that indicated by theory there is less pressure available for overcoming the resistance of the pipe. It is also shown that the minimum pressure at the pipe exit is limited so that the maximum discharge velocity does not exceed the velocity of sound.

Composite Metals

INDUSTRIAL AND ENGINEERING CHEMISTRY

INTRODUCING a symposium on new metals and alloys applicable to the chemical industry in the December, 1936, issue of *Industrial and Engineering Chemistry*, B. D. Saklatwalla, discusses the evolution of new metals, and has the following to say about composite materials.

Although the science of metals has progressed remarkably and the art of alloying various elements into metals has reached a high degree of accomplishment, the ultimate goal seems to be distant. In cases where a certain set of physical properties is required in the body of the metal, together with certain surface properties which the body does not possess, recourse is still had to composite materials. The art of plating a metal with a nobler metal by galvanic current is old. Gold, silver, and nickel have surfaced articles of household use. Recently, advances have been made in producing electrolytic coatings of zinc, lead, cadmium, and tin, and in some cases with bright finish. Also advances have been made in plating ferrous and nonferrous metals with chromium and with tungsten. Possibly tantalum will some day perform the same function.

Such galvanic deposits for chemical-engineering use have certain shortcomings, and there has been a persistent effort to produce so-called duplex materials whereby two metals are rolled together, the one for surface protection and the other for engineering strength. Copper- and nickel-clad steels have been successfully made and used in the chemical industry. Autogenous lead coatings on steel have been common. Only recently, however, have attempts been made to produce ordinary carbon steel with a surface of stainless steel or with a surface of aluminum. Aluminum alloys coated with pure aluminum for better resistance to corrosion have been produced. Metals have also been coated by spraying with a molten noncorrosive metal, but such coatings suffer from porosity and pinholes as do metals deposited electrolytically. Considerable advancement has been made in coating steels or high-tensile nonferrous alloys with nonmetallic substances, such as glass, enamel, plastics, or rubber. In such cases the metallurgist's services are required to produce the parent metal with a surface capable of making a solid bond with the lining material. Development of the technic of producing anodic oxide protective films on metals, as in the case of aluminum, is recent.

Mention should be made of the recent development of a new field known as powder metallurgy. Powders of various pure metals are produced and mixed in the proportions desired and pressed into a rod or briquette which is sintered, and the sintered product is then rolled or forged. This art may prove of considerable advantage to the chemical industry inasmuch as it permits the mixing of metals, independent of their inherent alloying solubility in each other. By this technic it is also possible to obtain a composition of the surface entirely different from the body of the sintered metal.

Great advance has recently been made in coating common structural metals with corrosion-resistant alloys by applying a fused layer of the nobler metal by means of the welding torch. The advancement in the technic of welding in the construction of equipment and in attaching linings to containers is due to the advance in metallurgy not only of the metals of construction but also that of the metal of the welding rod and the coatings used on the welding rods. The advance in welding technic has also made it permissible to construct welded equipment of rolled metal instead of using a casting, thus considerably diminishing the weight of the equipment and obviating the usual deficiencies of cast parts. This is particularly useful where it is advantageous to construct equipment requiring different properties in different parts. It is thus possible to use two or three different materials, each appropriate for the function. This would be impossible if a casting were used.

A new process of welding by high-frequency current has been announced. The metal is welded at a low temperature without being subjected to temperatures high enough to change the structure of the metal in the parts adjacent to the weld. This process becomes of great importance, especially in the welding of extremely thin sections or of low-melting metals.

Oil-Pad Bearings for Telescope

MACHINE DESIGN

FURTHER details of the bearings to be used in the mammouth 200-inch telescope which Capt. McDowell described so effectively in the June, 1936 issue of MECHANICAL ENGINEERING are to be found in *Machine Design* for December, 1936. J. Ormondroyd, member, A.S.M.E., whose book reviews in the *Journal of Applied Mechanics*, as well as frequent technical articles, have demonstrated his ability to write instructively for engineers, describes briefly the details of these bearings.

Readers who recall the enormous telescope tube with its horseshoe yoke and who realize that the instrument must rotate about its polar axis without the slightest vibration, either radially or torsionally, in order to prevent blurring of photographs and varying of the total light intensity entering the slit of the spectrographs, will be interested in the bearings that have been designed for this purpose. Mr. Ormondroyd says that the whole polar-axis bearing problem was solved in a simple and comparatively economical manner by using the construction shown in Fig. 3 at the north polar bearing. This north bearing floats in oil introduced at an average pressure of 250 lb per sq in. to four oil pads arranged two on each side of the vertical center line, Fig. 3. Each pad can adjust itself to local deflection by turning on a hardened seat; an equalizer bar rotating about a hardened-steel roller equalizes the load between the two contiguous bearings.

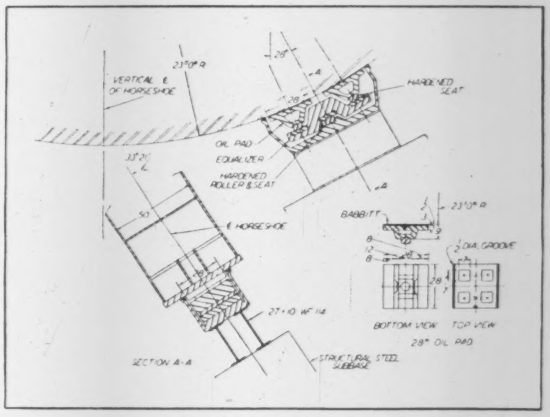

FIG. 3 CONSTRUCTION DETAILS OF NORTH POLAR BEARING

Oil is admitted to each pad through four separate orifices symmetrically placed in the carrying surface. The loaded surface is babbitted and about each oil-inlet orifice the babbitt is recessed. High-pressure oil flow to each inlet, provided by

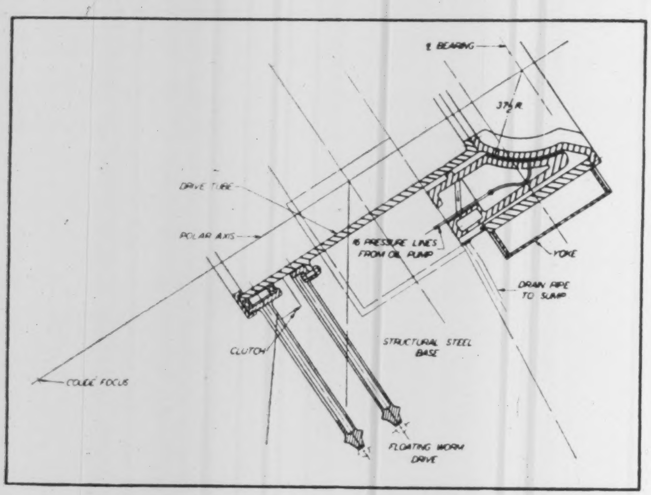

FIG. 4 CONSTRUCTION DETAILS OF SOUTH POLAR BEARING

positive displacement pumps, is governed by a fixed orifice or needle valve rather than by the oil gap to give stability of position for the pad through equal distribution. Air bells in the feed lines will keep the pressure completely steady at the supporting surface.

Fig. 4 shows how the same principle is carried out at the south bearing. Here the bearings consist of zones of two spheres, 75 in. in diameter, the one enclosing the other. These parts are of cast steel, babbitted. Oil-inlet orifices are so distributed that the bearing is centralized under the existing thrust and radial loadings.

Thus the whole million-pound precision instrument floats on oil. It is estimated that the flow of oil necessary to float the telescope with oil gaps about 0.003 in. thick will be so small that only $^1/_{15}$ hp will be needed to drive the pumps. Larger horsepower will be used, however, to overcome the friction in the feed lines and in the pump itself. More than one pump is available, the pumps being interlocked in such a way that should one fail the drop in pressure in the line will start the other. The telescope polar-axis drive will also be interlocked to the pumps in order to stop the drive in case of lubrication failure.

Polar and declination drives and gears are not yet designed, but it is estimated that a 0.5-hp motor will be sufficient to overcome inertia and friction in driving the mounting about the polar axis. At the regular operating speed of one revolution per day the horsepower needed to overcome the polar-axis bearing friction will have the unbelievably small value of 1/165,000 hp. Even with motor losses and gear friction the polar-axis motor will not draw enough current to give an indication on an ammeter.

Injection Molding

CHEMICAL AND METALLURGICAL ENGINEERING

INTRODUCING an article entitled "Economic and Engineering Trends in Plastics," in the January, 1937, issue of ***Chemical and Metallurgical Engineering***, A. F. Randolph calls attention to the fact that, as a result of research, changes in raw-material costs, the growth of new outlets, and the disappearance of old uses, many changes occur in the plastics industry from year to year. From Mr. Randolph's condensed summary of some of the developments, the following comment on injection molding is of interest.

The very recently developed technique of injection molding comprises the forcing of a molding compound heated in a reservoir to a fluid condition into a closed mold cavity and maintaining it under pressure in the mold until it is cooled sufficiently to be rigid. The mold is kept cool and the soft material forced into it sets to a rigid condition within a comparatively short time.

The molding cycle with an injection machine is shorter than that of compression molding, so that with a single mold cavity the hourly production of an injection-molding press is several times that of a compression-molding press. Commercially, however, more than a single mold cavity is used in either case, and the greater capacity of a compression-molding press makes possible the greater multiplication of the number of mold cavities, which tends to overcome the handicap of a longer cycle.

Noteworthy in the expansion of the fields of application of plastics has been the injection molding of small parts of delicate or complicated shape and the successful molding, by compression, of articles of size recently considered beyond the scope of the technique, such as cabinets and housings for radios, office machines, and merchandise scales.

In connection with Mr. Randolph's mention of injection molding, mechanical engineers note with interest the evolutionary development of machine-tools concurrently with the growth of molding technique. At least one manufacturer whose name older engineers will associate with the manufacture of lathes offers an injection-molding machine. This same manufacturer, when die-casting of zinc, aluminum, and brass offered production possibilities favorable to the making of parts formerly built up of machined elements, developed machines for this purpose.

Uses of Methacrylate Resins

MODERN PLASTICS

REFERENCE last month to the plastic "pontalite" may lead readers to turn to *Modern Plastics* for November, 1936, where H. R. Dittman writes on "Methacrylate Resins." Older engineers whose chemical education was largely confined to the organic branch of that science may view with alarm the equations which appear to be attempts to express a hearty sneeze in chemical symbols and may shy at remembering and pronouncing the outlandish polysyllables which intersperse any article on plastics, but they will find interest in the tabulations of properties and the following comments on applications and uses.

The transparency, strength, high softening temperature, low specific gravity, and chemical resistance of polymethylmethacrylate make it an outstanding plastic material of either the cast or molded type. The unusual clarity of this resin permits its fabrication into delicately tinted shades. With the combined use of dyes and pigments, materials of varying degrees of color and transparency have been prepared. The value of this resin is greatly enhanced by the ease with which it can be worked, engraved with unusual effects, and cemented to itself to give joints which for all practical purposes are as strong as the resin itself. Methylmethacrylate is readily molded in compression molds under the same conditions used for other thermoplastic resins. Molding powders suitable for use in injection molding are being developed.

The glass-like transparency of these resins suggests many uses as glass substitutes where strength, lightness, ultraviolet transmissibility, and ease of fabrication by molding are desired. Their substitution for glass in certain uses is facilitated by the remarkable chemical inertness of these resins. Among the many uses which have been evaluated and patented in the plastics field are safety-glass interlayer, sound-recording records, dentures, and telephone and radio transmitter diaphragms.

The low viscosity of the monomeric esters of methacrylic acid, together with the ease with which they can be polymerized, adapt them as impregnating agents which can be polymerized *in situ*. Various porous, fibrous, and cellular materials, such as wood, cloth, wallboard, transite, cork, paper, electrical coils, stone, and tile, have been successfully impregnated in this way to obtain products with increased water, oil, alcohol, acid, and alkali resistance. Monomeric methylmethacrylate has been used to impregnate wood to give a final product containing as much as 60 per cent by weight of resin. Catalyzed monomer is readily absorbed by evacuated wood (pressure facilitates the impregnation, but is not necessary), following which the wood must be heated for several hours at elevated temperatures to polymerize the resin. Wood so treated has improved strength and is resistant to warpage, water absorption, and the action of chemicals.

The dielectric properties of methylmethacrylate resin make it of value in the electrical-insulation and instrument field. Here again the transparency, noncracking qualities, inertness to ozone, high softening temperature, strength, water, oil, and chemical resistance, and the decrease of power factor with increase in temperature, combine to make this material of unusual interest. The monomer can be used to impregnate tightly wound electrical coils, following which the resin can be polymerized to give a thoroughly resin-filled appliance from which no solvent remains to be expelled. The fluidity of the monomer permits very rapid impregnation. Solutions of the polymer can be used also for the impregnation of coils, particularly where complete sealing is not necessary. Rotors and armatures can be dipped in resin solutions to bond the wires firmly in place. The toughness and strength of methylmethacrylate resin give it the ability to prevent movement of the wires under the centrifugal force developed at high rotational speeds.

Methacrylate resin treated paper and cloth have many uses. Paper, cloth, wire, and other flexible materials can be impregnated with resin monomers, followed by polymerization *in situ*, coated with solutions of the resin polymers, or impregnated with aqueous resin emulsions. Paper and cloth treated in this manner become water, oil, alcohol, inorganic acid, and alkali resistant with the result that these materials become of value in the electrical and food-packaging industries. The treated paper and cloth can be laminated to obtain white, translucent sheets which are both strong and flexible. Because of these qualities and the low specific gravity of these resins, laminated stock prepared from them as well as the resins *per se* are of value to the aircraft industry. Methacrylate resin laminated paper and cloth can be dyed or pigmented to give colored translucent sheet stock which can be employed with marked success in the fabrication of lamp shades. These resins have found application in the textile field as sizing and stiffening agents.

Their clarity, light resistance, water impermeability, alcohol, oil, alkali, and acid resistance, and general compatibility suggest many applications in the specialty coating composition field. The polymers dissolved in aromatic hydrocarbons, esters, ketones, or chlorinated hydrocarbons can be applied by spraying, brushing, dipping, or roller coating. Although any of the methacrylate resins can be used for this purpose, *n*-propyl, normal- and iso-butyl, or interpolymers of methyl with the softer resins are more readily adapted to general finish uses. Klein and Pearce have included the study of polyethyl methacrylate and ethyl methacrylate methylacrylate interpolymer films in their investigation of the film-forming properties of acrylic-acid resins. The extensibility and elasticity of poly-*n*-propyl and poly-*n*-butyl methacrylate films, particularly the latter, more closely resemble polyacrylate than polyethyl methacrylate films used by their investigators. Although the adhesion of methacrylate polymers is good, it is improved by baking.

These are but a few of the many uses where the unique properties of the methacrylate resins can be employed to advantage in almost every field of industrial endeavor.

For a Bright Young Man

THE SATURDAY REVIEW OF LITERATURE

A HINT for a bright young engineer is given in an editorial in the January 9 issue of *The Saturday Review* entitled "How to Be a Publisher (1)." The purpose of calling attention to the editorial is not to urge engineers to become publishers but to set them thinking about the problem of the weights of books. Says Mr. DeVoto in the editorial:

Lightness of material, economy and simplicity of design, convenience of use, and sensible adaptation of the product to its function characterize production nearly everywhere. But in the twenty years during which this trend has been accelerating, the printed book shows no such progress. The means of producing it have enormously improved. The modern printer has at his disposal processes more sensitive, more flexible and versatile, and more subject to control than he had even ten years ago—and in the reproduction of illustrations, processes superior to those of even two years ago. If you follow "Penrose's Annual" and similar reports, you are aware of a continuous advance in mechanical efficiency, economy, and excellence. Meanwhile libraries and other uncommercial users of books are developing processes that supplement and amplify the conventional ones of printing. So far as the mechanics of the job are concerned, any conceivable end may now be achieved. Books do not have to be bound in cloth or boards, they do not have to be bound at all, they do not have to be printed on paper, they do not, in fact, even have to be printed. Any effect that a vigorous imagination may set itself is easily within the means of modern technology. The only experiments they will permit the designer are concerned with type faces and the arrangement of type on the page, and he would be an optimistic soul who asserted that any essential improvement is discoverable in either.

Suggest to any publisher in America that he bring out a big book in a light format, and he will tell you that the public won't stand for it. When the public pays three dollars for a book, he informs you, the public wants mass. The public knows a book is good if it can see that it weighs three pounds. The public knows that it is getting its money's worth if its arm cramps, carrying it home. The public judges a book by size and weight, demanding big books for big money. . . . . . Also, if you believe publishers, the public will not buy books because it has no room for them in the modern apartment.

If you back a publisher into a corner of his office and make him consider the problem of weight more closely, he will agree that something ought to be done but will plead his helplessness. The experiment with paper-bound books failed, he will point out—though it was tried half-heartedly, with unimportant books, and especially with books that were not out-size anyway. He cannot get light paper, he informs you. British and French publishers can get it and they bring out long books at half their American weight. But that is (*a*) cheap paper or (*b*) expensive paper and the American public won't stand for it—the experiment never having been tried. Or American manufacturers don't make a satisfactory light paper. Well, the orders of American publishers are big enough to force the paper industry to meet any specifications whatever, or, if that industry is lethargic, the Duponts or the Aluminum Company of America would be happy to investigate so promising a market. Here the publisher retires on his earliest declaration: the public won't stand for innovation.

Suggested procedure: the manufacturer of any other product calls in a designer, sets out the specifications he has in mind, and tells him to go ahead. Prophecy: some day a publisher will call in a designer, show him a manuscript that would weigh four pounds if printed in the ordinary way, and tell him to make a book of it that does not weigh more than sixteen ounces. Further prophecy: Whether it comes out on duralumin sheets, in a cellophane roll, or in the format of a Japanese fan, it will sell five million copies. Still further prophecy: Publishers will then unanimously decide that that is the only kind of book the public will buy.

Engineering in Public Affairs

AMERICAN ENGINEERING COUNCIL

FROM the concluding section of the 1936 annual report of the executive secretary, F. M. Feiker, of the American Engineering Council, the following excerpts have been taken. They appear under the caption "Opportunities for Engineering Statesmen" and are significant not only as a forecast of the tasks before the present Congress but as an indication of the broad view taken by the Council and voiced by Mr. Feiker, on public affairs.

In the minds of most commentators on the national election, the overwhelming note of confidence given to the national administration means that the people by a large majority have asked the government to take the responsibility for insuring national and personal economic welfare, never before expected by the people of their federal government. Public opinion in earlier times has, without regard to party, supported the philosophy that the best government was the least government. Now, apparently under the stress of a long depression, public opinion supports the idea that the government can do for business and for individuals what they have not all been able to do for themselves.

To meet this newly created responsibility is a task in which the experience and judgment of every creative-minded group of our people should share. And of such groups, none have greater need of making their opinions known than the engineer citizens. In the capital-goods industries, such as machinery and construction, engineers are engaged not only as men qualified in the several technical branches of the profession, but as managers and enterprisers heading the policies of individual companies. In the public-utility fields, including the railroads, electrical, and communications, engineers also find their individual places both as technicians and as managers. In the extractive industries, mining and petroleum engineers are not only technically employed but are found as promoters and managers of enterprise. Many specialized branches of industry, moreover, such as chemical and automotive industries, as a group are manned by professional men who approach the problems of both management and technology as men trained in the engineer's factual approach to the analysis of their problems.

As always, hundreds of new bills will be introduced into the new Congress. Many will have to do with the economic and social welfare of the people. Changes in present laws will also probably be made to improve the procedures of earlier legislation. Of the many hundreds of bills which will be introduced, five broad categories of legislation offer the engineer citizen a special opportunity for consideration in the public interest. They concern federal supervision and support of the unemployed, and the determination of relief policies, many of them dealing directly with engineering works; the improvement of procedures for operating old-age pensions and unemployment compensation under the Social Security Act; the development of legislation in the field of federal control of output, of wages, of conditions of employment, and of price in the fields of industry and trade; the improvement of present laws and proposals for others in the supervision and development of our natural resources; the determination of a federal public-works policy and the coordination of national, state, and local public-works programs; federal relations to public and private farm electrification; and finally, the improvement of federal government organization and personnel both from the viewpoint of improving the efficiency of the government agencies eliminating duplication and waste and of providing for careers under the civil service.

It seems of first importance next year therefore, that our plans take into account these public expressions of approval and that we should make every effort to bring engineering thinking, in its relation to social security, before the public.

Skilled-Labor Shortage

OCCUPATIONS

SHORTAGE of skilled labor is a topic discussed frequently in times of industrial revival like the present. Donald M. Cresswell, in *Occupations* for February, 1937, reviews some of the comments on this subject that appeared in the press during the closing months of 1936. Mr. Cresswell says:

Various reasons have been advanced for the seeming lack of trained workers. Chief among them is reference to the more than five years of the depression when few men were trained in the skilled trades. Other reasons include the fact that restriction of immigration has reduced the number of skilled workmen coming to the United States from other countries; many skilled craftsmen, due to layoffs in the depression years, have deserted their trades to follow other lines of endeavor; others have been lost to industry through retirement and death, at a rate estimated at 5 per cent annually, or 30 per cent for the depression period. These reasons do not hold true in all classifications, some writers and speakers indicate, but it is admitted that in many instances today it is difficult to obtain "properly trained" men for replacements, especially in the metal trades. New machines and methods of operation also are declared to be a factor, men skilled on old machines finding they cannot go back without special training.

Attention is then invited to the announcement on Dec. 13, 1936, by the Carnegie-Illinois Steel Corporation of the proposed expansion of its apprentice program, to a series of articles in the *American Machinist* describing training activities in eight companies, to a survey of the nation's relief and unemployment situation reported by Louis Stark in *The New York Times*.

In conclusion it is stated that since expansion of apprentice training obviously is an important phase of recovery from the skilled-labor shortage problem, the part to be played by the school becomes most important. Suggestions for such an approach were developed at the December meeting of the New York Vocational Guidance Association. Speakers representing education and industry decided that apprentice training which includes supplemental education in the public schools is superior to either "learning by doing" or vocational education that is divorced from an actual position. It was pointed out that large numbers of trainees are taken in hand by the smaller industries, those who can use only from one to five apprentices. With larger industries utilizing their own equipment and that of the schools, there remains to be made a closer tie-up between school and small industry, not overlooking the important part that trade unions could and should play in helping to guarantee a constant future supply of competent, skilled craftsmen and women, soundly and suitably educated in mind as well as in skills of the hand.

Appreciation of Coulomb

THE NEWCOMEN SOCIETY

AT A meeting on Dec. 16, 1936, of the Institution of Structural Engineers, Stanley B. Hamilton, member of the Council of the Newcomen Society for the study of the history of engineering and technology, delivered an address on "Charles Augustin Coulomb," a centenary appreciation of a pioneer in the science of construction. Mr. Hamilton referred to the address on Coulomb by S. C. Hollister, published in MECHANICAL ENGINEERING for October, 1936. Commenting on Professor Hollister's estimate of Coulomb's useful life and noble character, Mr. Hamilton said, "No equally concise and informative eulogy of Coulomb has hitherto appeared in English." He then summarized Coulomb's contributions to the theory of structural engineering as follows:

In considering the strength of materials he realized that brittle materials, subjected to crushing, fail in shear. His attempt to calculate the one in terms of the other was vitiated by his assumption, based on slender experimental evidence, that cohesion, whether direct or transverse, was the same; but the broad principle was a new and important discovery.

He recognized, at least implicitly, the truth of Hooke's Law, and gave it its true place in elastic theory.

His theories of bending and twisting, although incomplete from the standpoint of later elastic theory, were a sound contribution to knowledge, and still provide the basis of everyday calculations.

By a stroke of genius he anticipated the view, although his age lacked the technique to verify it, that elastic strains are due to distortion of the space lattice within a crystal, while plastic deformation and fracture are due to the development of slip planes.

He derived the only satisfactory *simple* method of calculating the thrust of earth against a retaining wall.

He made a sound contribution, although it was later to be superseded by more direct methods, toward the investigation of the stability of the masonry arch.

Perhaps no writer on construction before or since rendered so much previous theory obsolete. In short, with Coulomb the theory of structural engineering enters upon its modern phase. To every subject he touched he brought a virile, original, scientific mind, tempered by practical experience; and it is most fitting that, in this bicentenary year of his birth, we should do homage to one of the greatest pioneers of a profession which has a history as long, and as worthy of record, as that of any other branch of engineering.

Whither the Railroads?

CHARLOTTE SECTION, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

TAKING as his subject "Past, Present, and Future of Railroad Transportation," J. E. Teal, transportation engineer, Chesapeake and Ohio Railroad, commented on trends and predicted developments to the Charlotte Section of The American Society of Mechanical Engineers on Jan. 15, 1937.

Mr. Teal had a good deal to say about the much discussed subject of research in the railroad field and made out a very good case for the railroads and the railway-supply industry, pointing out some of the factors that affect the railroad problem that are unimportant considerations in other industries.

Interesting statistics on mileage scheduled in excess of 60 mph gave evidence of the general speeding up of railroad traffic that has been so popularly discussed during recent years. Steam locomotives, in daily operation, at speeds in excess of 60 mph cover 14,134 miles. Electric locomotives operating above this speed range are covering 8322 miles, and Diesel-electric locomotives 17,749 miles, of which 6845 miles are on daily schedule.

Forecasts on freight service were made by Mr. Teal as follows:

The tendency will be toward faster and more frequent operation of trains, although heavy-tonnage trains will continue to have their place. Less-than-carload express, car-forwarder, and less-than-carload traffic will be combined, concentrated, and handled in more heavily loaded cars of shockproof construction and moved at passenger-train speeds. The distribution at either end will probably be done by trucks, probably to and from railheads usually located outside of the crowded city areas. An intermediate service, between the present less-than-carload and car-load services, will be developed by the use of containers carried on flat cars. They will be of lightweight construction, of uniform types, and capable of interchange between all railroads, and between railroads and motor trucks or water carriers. Some of them will be adapted to special services, including refrigeration.

He quoted John J. Pelly, president of the Association of American Railways, as saying that "the major uncertainty as to the future of railroads is not their own operations or methods—not in what they may be able to do for themselves. It is in the field of public policy. Will our public policies as to transportation allow railroads equal opportunities to compete for a sufficient share of the business money?"

On how this question is answered, said Mr. Teal, depends in a large measure the future of the railroads.

The railroads are, and will continue to be, essential, he continued. The railroads are alert in bettering service and cutting unit costs. Their efficiency is such as, with normal volume, makes possible the continued operation on a self-supporting, profit-making basis, and there is good ground for belief that in equities in public policy which have had the effect of reducing traffic, volume and railroad costs are on the way toward correction.

In Mr. Teal's opinion the railroads will continue to furnish the major part of the nation's transportation requirements, and they will always be ready to provide the public what it wants and is willing to pay for, in service and comfort, at the lowest cost possible. Railroads will continue to change, but will not do so overnight.

LETTERS AND COMMENT

Brief Articles of Current Interest and Discussion of Papers in Previous Issues

Corrosion-Resistant Metals

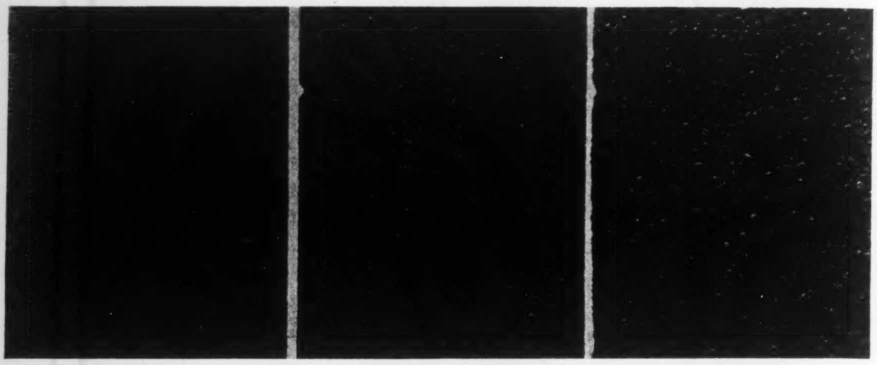

FIG. 1 THREE SAMPLES OF STEEL AFTER THREE YEARS OF EXPOSURE TO AN INDUSTRIAL ATMOSPHERE, COR-TEN, COPPER STEEL, PLAIN STEEL

(The marked difference between the rust on the Cr-Cu-Si-P steel at the left and that on the other two samples should be noted. At the time these photographs were taken, the rust had not been disturbed.)

To the Editor:

Atmospheric corrosion accounts for a large part of the heavy economic loss mentioned in Dr. Speller's paper.[1] For years, many investigators have been searching for a quick method of testing metals, particularly steels, to find which type best resist the destructive industrial atmospheres of our large cities and manufacturing areas. The most popular one for many years was the acid test. This was sufficiently rapid but unfortunately did not give results that were even reproducible, much less comparable to atmospheric exposure. The American Society for Testing Materials has demonstrated this conclusively by extensive experimental work, having conducted for 20 years an exposure test of uncoated steels and irons at Annapolis, Md. None of the 16-gage sheets shows perforations after this exposure even though many of the 22-gage specimens, which represent the same types of materials, have failed.

From this test, the relative merits of several kinds of iron and steel, with respect to their corrosion resistance in this kind of atmosphere, have been learned. In spite of the failure of the acid test to give accurate results, thousands of dollars have been spent in a futile effort to develop a laboratory test that would place steels in the same order of merit as that found by such lengthy exposure tests.

Relative corrosion resistance is about all that can be determined from atmospheric exposure tests. Experience has shown that a group of metals exposed at one time cannot be compared with the same or another group exposed at a different time even at the same location. For instance, nine steels[2] exposed to an industrial atmosphere from November of one year to November of the next year lost nearly twice as much weight as the same steels exposed at the same location from July to July. These and many other similar results have led to what should be almost an axiom in corrosion testing: To obtain comparable results, the material must be exposed at the same time, in the same manner, for the same period of time, in the same environment. The elimination of all possible variables must be the aim of those who study this subject.

Dr. Speller referred to films protecting metals and cited the invisible film on stainless steel as an example. In atmospheric corrosion, at least of plain and low-alloy steels, a thicker type of coating develops which in some cases is very protective. Fig. 1 shows three samples of steel, rust intact, after exposure to an industrial atmosphere for three years.

Attention is directed to the remarkable difference between the rust on the steel at the left and the other two samples. This chromium-copper-silicon-phosphorus steel has a very adherent and impermeable coating of rust. That this difference in appearance is a good criterion of the greater protection furnished the steel by the more adherent layer of rust, is clearly demonstrated in Fig. 2, where the corrosion losses of two steels are plotted against the time of exposure to an industrial atmosphere. Each point on the curves represents a single sample. The samples were initially exposed at the same time and removed from the test after the designated period of exposure. Both materials lost weight with comparative rapidity in the first few months of the test. Then, as the resulting oxides gradually assumed their protective rôles, the differential effect of these oxides became evident.

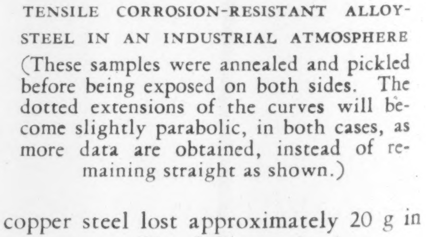

FIG. 2 CORROSION RESISTANCE OF A COPPER-BEARING STEEL AND A HIGH-TENSILE CORROSION-RESISTANT ALLOY-STEEL IN AN INDUSTRIAL ATMOSPHERE

(These samples were annealed and pickled before being exposed on both sides. The dotted extensions of the curves will become slightly parabolic, in both cases, as more data are obtained, instead of remaining straight as shown.)

In this test, started in October, the copper steel lost approximately 20 g in two years. The difference in the corrosion between tests started at different seasons is shown by the fact that a sample of the same material initially exposed in April at the same location lost approximately 15 g in two years. The lower curve shows that the rate of corrosion of the particular steel has been greatly retarded by the dense tightly adherent coating of rust similar to that shown in Fig. 1. The tendency of these curves to flatten is the basis of the present development of all low-alloy corrosion-resistant high-tensile steels. As a result of American Society for Testing Materials tests and other service tests, copper steel is acknowledged to have about twice the average life of plain steel.

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[1] Corrosion-Resistant Metals," by F. N. Speller, Mechanical Engineering, vol. 58, December, 1936, pp. 781–783.

[2] "The Influence of Rainfall and Smoke on the Corrosion of Iron and Steel," by G. N. Schramm and E. S. Taylerson, Symposium on the Outdoor Weathering of Metals and Metallic Coatings, American Society for Testing Materials, 1934, pp. 51–68 and 110–113.

To those who say "But steel is always painted," we cite the research bulletins of the New Jersey Zinc Co., Dr. J. S. Unger's paper presented before the Rail-Way Club of Pittsburgh, April 26, 1928, and more recently the Fourth Report of the Corrosion Committee of the British Iron and Steel Institute, all of which show that painted surfaces of copper steel hold the paint better and, hence, are more resistant to corrosion than plain steel. The reason, of course, is that the rust on copper steel is tighter and less permeable to moisture. By the same reasoning, we deduce that paint on the surfaces of still more-resistant steels will be less likely to break down than paint on copper steel.

The development of low-alloy steels is not a new one. Copper steel was first commercially promoted[3] in 1913 and adopted by a leading eastern railroad for all rolling equipment in 1920. Other alloying elements have been used for many years to make steels for special purposes with the accent placed on strength. The use of $3^1/_2$-per cent nickel steel for bridges, the chromium-molybdenum steels for oil-cracking stills, and the host of alloy steels used in the automotive and other industries are examples.

TABLE 1 PHYSICAL PROPERTIES OF LOW-CARBON STEEL AND OF LOW-ALLOY HIGH-TENSILE STEELS IN SHEETS AND STRIP

Physical properties	Regular open-hearth	Cr-Si-Cu-P steel
Yield point, lb per sq in.	25,000 min to 35,000 min	50,000 min to 60,000 min
Tensile strength, lb per sq in.	35,000 min to 50,000 min	65,000 min to 75,000 min
Elongation in 2 in., per cent	34 to 25	27 to 22

As a matter of fact, the mills now supply alloy steels containing exactly what the consumer is willing to pay for. The ideal is to have a steel that will do the job at the lowest possible ultimate cost. Recently, as more interest has been taken in corrosion resistance, many experimental steels have been made and tested for comparative corrosion resistance and physical properties. An interesting comparison of one of these with open-hearth steel is given in Table 1.

The economic success of the high-tensile-steel passenger trains and the rapid growth of the streamlined type of transportation equipment is well-known. Where the economic factors did not seem to justify using stainless high-tensile steel, as in freight equipment, the strong low-alloy corrosion-resistant steels received early recognition and are playing an important part in present replacement programs. Open-top freight cars obviously are the worst offenders with respect to corrosion losses because their unpainted interiors are exposed to the weather, and here the comparatively cheap alloy-steels have tremendous possibilities.

Approximately 80 per cent of the corrosion of railroad hopper cars in coal service has been shown[4] to be due to atmospheric corrosion and about 20 per cent to the leachings that come from the coal, improper design, and other causes. The length of time that coal is stored in the average car has been calculated, from data published by the Federal Coordinator of Transportation,[5] to be not longer than an average of three or four days. As the leachings from stored coal do not become very corrosive until after three or four weeks, the assumptions on which the calculations are based can be changed considerably without affecting the relative loss which is caused by the atmosphere.

As the copper-chromium silicon-phosphorus high-tensile steel shown in Fig. 2 has twice the estimated life of copper steel and as its resistance to the action of coal leachings has been found to be about 40 per cent greater than that of copper steel, advantage can be taken of its higher strength to make hopper cars much lighter in weight than those now generally used. Yet, due to its much better relative corrosion resistance, the estimated life of these thinner sections will be equivalent to or longer than that of conventional copper-steel sections.

The additional resistance of this low-alloy high-tensile steel, over and above that of copper steel, has been noted in fields other than that of atmospheric corrosion. Space will not permit discussing the investigations that have shown the noteworthy performance of this product when compared with copper steel in sea water, brine solutions, and alternate atmospheric and brine conditions such as might occur around refrigerator-car roofs and icing platforms.[6]

Approximately eight common metallic alloying elements are generally used in ferrous metallurgy, and the comparatively small variation of some of these produces a really unique material. That many low-alloy high-tensile corrosion-resistant steels are on the market and that many more have been made experimentally is not, therefore, to be wondered at. The metallurgist continually endeavors to place new materials at the disposal of the engineers and to do it well within the limits of economic feasibility.

E. S. TAYLERSON.[7]

TO THE EDITOR:

Mr. Anderson's presentation[8] of the rôle of zinc as a protective coating for steel is clear and precise, and the data given in his paper should render the estimation of the economics of zinc protective coatings for exposure to a wide variety of atmospheric conditions a simple matter.

Data taken from American Society for Testing Materials reports have been used to illustrate the rate of corrosion of zinc coatings and the effects of environment on this rate.

It should be emphasized that the complete reports from which these data were obtained should be carefully scrutinized before broad and sweeping conclusions are made. For example, the bar chart taken from the report of Sub-Committee 8 of Committee B-3 of American Society for Testing Materials indicates a very high rate of corrosion for zinc-iron couples at LaJolla, Calif., as compared with that noted at Phoenix, Ariz. The precipitation, as measured by rainfall gages at these two points, is approximately the same.

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[3] "Copper in Steel—The Influence on Corrosion," by D. M. Buck, *The Journal of Industrial and Engineering Chemistry*, June, 1913, vol. 5, pp. 447–452.

[4] "Corrosion of Steel Cars by Coal," by G. N. Schramm, E. S. Tylerson, and C. P. Larrabee, *Railway Age*, vol. 101, Nov. 28, 1936, pp. 780–785.

[5] Freight Traffic Report, 1935, vol. 1, p. 88. U. S. Federal Coordinator of Transportation, Washington, D. C.

[6] "Cor-Ten—a High-Tensile Corrosion-Resisting Steel for Railroad Equipment," by R. F. Johnston and G. N. Schramm, Proceedings of the Railway Club of Pittsburgh, Nov. 22, 1934, pp. 19–36. "New Alloy-Steels and Their Application to Car Equipment," by G. N. Schramm, E. S. Taylerson, and A. E. Stuebing, *The Iron Age*, Dec. 6, 1934, pp. 33–38. "Modern Steels and Weight Reduction," by J. C. Whetzel, Yearbook of the American Iron and Steel Institute, 1935, pp. 104–133.

[7] Research engineer, Carnegie-Illinois Steel Corporation, Pittsburgh, Pa.

[8] "Zinc in the Chemical Industry," by E. A. Anderson, MECHANICAL ENGINEERING, vol. 58, December, 1936, pp. 799–802.

Heavy sea fogs roll in every night at LaJolla and these fogs carry salts in solution which are deposited on the specimens. As very little precipitation occurs to wash the resultant accumulation of corrosion products from the surface of the specimens, they remain and become completely saturated with moisture. Solution and electrolysis proceed at a rapid rate under these conditions.

This case is mentioned to illustrate the importance of local conditions on the rate of corrosion.

Mr. Anderson mentions the importance of the nature of films that form on zinc coatings and their effect on the subsequent rate of corrosion. Freshly galvanized materials have been observed to corrode rapidly when exposed under atmospheric conditions designated as "heavy industrial."

Zinc coatings that have been permitted to build up an adherent oxide coating before they are installed under such conditions, deteriorate at a lower initial rate. Films of this type can be produced by synthesis, as mentioned in Mr. Anderson's paper, by treatment of the zinc with dichromate solutions, and by other means. The usual method is to store the zinc-coated material under reasonably dry conditions for a few weeks prior to installation.

During the verbal discussion of Mr. Critchett's paper,[9] mention was made of the influence of cold work on the rate of deterioration by corrosion of alloys of the 18 per cent chrome 8 per cent nickel type. The fact has been established beyond doubt that cold work or work hardening does influence the solution rate of this material when subjected to severe corrosion conditions.

This alloy finds increasing usefulness under conditions of normal atmospheric exposure or sea-water and sea-air exposure. Hard-drawn wire having a tensile strength in excess of 300,000 lb per sq in. fabricated into wire rope and strand has been used continuously in many marine applications for eight years without loss of strength. A rapidly increasing demand for this material indicates that it is satisfactory for these conditions. Another interesting application of this material is its use in wire-rope conveyers at temperatures of 850 F. It retains its cold-work strength at this temperature, whereas other materials depending upon cold work for the development of comparable strengths are relatively unstable.

L. W. HOPKINS.[10]

TO THE EDITOR:

Mr. Hiers is to be commended upon his interesting paper[11] in which he has assembled so much useful information about lead. Discussing the use of lead and its alloys in cable sheathing was not within the scope of his paper. However, the corrosion problems arising in the use of lead in chemical equipment bear some resemblance to those encountered in the field of cable sheathing. In the last 15 years, more than 2,000,000 tons of lead has gone into the cable plants of the communications and power industries. The physical properties of lead, notably extrudability and flexibility, dictate the use of lead and its alloys for sheathing, yet corrosion resistance is an essential property. Lead and its alloys appear to be the only suitable material for cable sheathing, both from the standpoint of physical properties and corrosion resistance.

Mr. Hiers states that lead alloyed with 3 per cent of tin appears superior in corrosion resistance in some soils. In a study of soil corrosion that was made in five typical soils in Indiana, we observed that this alloy was either equal or superior to lead in three locations, equal in a fourth soil, but considerably more corroded than lead or any of its alloys in the fifth soil. In general, the character of the soil appears to be considerably more important than the composition of the metallic material. The composition of cable sheathing probably cannot be modified to make it resistant to all soil conditions.

Underground cables are generally housed in conduit and do not come in contact with the larger soil particles which corrode the sheathing by setting up differential aeration cells. Fine silt and clay, borne by underground waters and coming in contact with cable sheathing, are not corrosive, but appear to inhibit corrosion by a mechanism somewhat analogous to that of certain inhibitors used in the pickling of iron. Soluble silicates in underground soil waters are probably one of the most effective protective agents for cable sheathing, although sulphates and carbonates are both influential. In the air, the protective film is apparently an oxide that can attain sufficient thickness or continuity within a few hours to protect the freshly scratched surface.

From 0.03 to 0.1 per cent of calcium produces an alloy having from two to three times the tensile strength of lead, which is more nearly like lead chemically than most the other common lead alloys, and which should have many uses in chemical equipment. Laboratory tests of this material in the form of cable sheathing have shown greater resistance to fatigue failure than other alloys. This alloy, when used as grids in storage batteries, produces a cell that holds its charge longer and sulphates less readily than the commonly used lead-antimony alloy.

I agree completely with Mr. Hiers regarding the limitations of the flash test to determine the durability of lead. It furnishes dependable information only on the behavior of lead in hot sulphuric acid but is of little or no value in predicting the resistance of lead when used as cable sheathing or in many other commercial applications.

R. M. BURNS.[12]

TO THE EDITOR:

In my contact with the chemical industry, I have gained the impression that the chemists are continually ahead of the metallurgists in demanding equipment to withstand exceptionally severe corrosive conditions and, in addition, they often require the product to be free of contamination. Choice of metals, in such cases, is usually limited to the so-called precious and rare groups. Until a few years ago, tantalum was rare in fact as well as in name. Today, however, its chemical-group name has no more significance than the term "base" when applied to nickel, or "precious" to silver.

About seven years ago, the producers of tantalum discovered how to fabricate it into the simpler forms. Since then, progress has been so rapid that, today, they are producing complete units of process equipment. Complete heat exchangers, steam coils, stills, condensers, thermometer wells and bulb sheaths, autoclaves, and many other items too numerous to mention are now available. This development is important to the mechanical engineers, because it places at their disposal either complete or partial units made from a metal that has the corrosion resistance of glass of ceramics, combined with the strength or steel, and, in addition, possesses the unique property of maintaining an extraordinarily high coefficient of heat transfer. The comparison of tantalum with ceramics can be taken literally. Both are practically inert to acids, except hydrofluoric, and fuming sulphuric acid, which attack tantalum even when cold.

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[9] "Corrosion-Resistant Stainless Steels and Irons," by J. H. Critchett, MECHANICAL ENGINEERING, vol. 58, December, 1936, pp. 823–826.

[10] Materials engineer, American Chain Co., Bridgeport, Conn.

[11] "Corrosion-Resistant Lead, Equipment," by G. O. Hiers, MECHANICAL ENGINEERING, vol. 58, December, 1936, pp. 793–798.

[12] Assistant chemical director, Bell Telephone Laboratories, Inc., New York, N. Y.

Tantalum is a valuable metal, and so is usually applied as a thin liner to steel or alloy casings. Steam coils, however, are a notable exception, because they are strong enough to withstand even very severe unbalanced pressure conditions without reinforcing and because lining or casing them with another metal would impair their heat-transfer efficiency. This use of thin metal, from 26 to 30 gage, for chemical equipment, distinguishes tantalum from almost all other metals, because no allowance for corrosion is necessary. Our company will not recommend it for any job having a perceptible corrosion rate. When we consider that ferric chloride can be evaporated and crystallized or aqua regia or muriatic acid boiled in containers made of tantalum without even touching its surface polish, then we begin to comprehend its importance.

Fortunately, tantalum is soft and ductile and can be formed, drawn, and stamped as readily as mild steel. The structural elements from which all tantalum equipment is made are sheets, rods, and seamless tubing. Joints are made by variations of the standard electric-welding processes that have been adapted to the characteristics of this metal.

F. L. HUNTER.[13]

TO THE EDITOR:

If I remember correctly, Mr. Wilkins, in presenting his paper,[14] made the statement that where the brass or bronze alloys are to be used in connection with corrosive liquids, the copper content should not be less than 85 per cent. Yet, we are all familiar with the fact that condenser tubes used along the coast where corrosive salt water is a circulating medium, very rarely, if ever, contain more than 80 per cent of copper.

Also, the author at least implied that a hard or high-tempered metal will withstand corrosion and impingement attack better than will the soft metal. He also pointed out that the English method of making tubes leaves them hard. In view of the English method of supplying a hard tube and the statement that a hard metal will withstand corrosion better than the soft metal, why do practically all American manufacturers always anneal their tubes so as to supply a soft metal?

Mr. Wilkins pointed out that, where a hard tube is supplied, often the practice is to anneal the end for rolling and possibly electrolytic cells are set up between the hard portion of the tube and the annealed portion, resulting in disintegration of the metal. I have some condenser tubes that were finished hard by an English company, one end of the tube was annealed for rolling in the tube sheet, the other end was left hard as one sheet was packed. These tubes were installed in a two-pass condenser, the annealed end being rolled into the inlet end of the tube sheet in the first pass, but the inlet end of the tubes in the second pass is at the packed end of the tube and, therefore, this inlet end had the hard metal.

Our principal cause of tube failures results from what is known as erosion corrosion or impingement attack, occurring within the first 3 or 4 in. of the inlet end of the tubes, and on the particular tubes mentioned, the hard tubes that had been annealed on the inlet end showed disintegration from impingement attack, whereas the inlet end of the second pass, where the tubes were hard, did not show this attack.

M. H. CURLEY.[15]

TO THE EDITOR:

With reference to Mr. Curley's comments in the foregoing letter I attempted, in presenting the paper, to differentiate between direct chemical attack and corrosion as aggravated by entrained air, impingement, and erosion. The brasses containing 85 per cent of copper or more do not dezincify, whereas the higher-zinc brasses do tend to dezincify under mild chemical attack.

Admiralty metal and other high-zinc alloys have been extensively used for condenser tubes and probably will continue to be used in this application. Satisfactory condenser-tube service is measured in terms of years. The action is not an active chemical attack but consists of a mild attack usually complicated by the action of entrained air or by impingement or erosion. Nevertheless, cases are frequent where failure of condenser tubes because of dezincification is observed and, in such cases, 85/15 brass is frequently recommended. In cases where operating temperatures are high, dezincification of the higher-zinc alloy-tubes is frequently noted, and 85/15 cupro-nickel and other special alloy tubes are used as replacement.

I commented on the English method of finishing condenser tubes hard and stated that, while visualizing any alteration in the resistance of the material to actual chemical attack was difficult, the hard tube might offer some advantage in resisting impingement. Mr. Curley's own observation would appear to substantiate that opinion to some extent.

The American practice, however, of annealing condenser tubes was based originally on a desire to prevent possible season-cracking of the higher-zinc alloy-tubes. The English tube-mill practice is largely based on mandrel drawing, and tubes so drawn do not exhibit the same tendency to season-crack as plug-drawn tubes which are standard in this country, and, hence, the necessity upon which the American annealing practice was based does not exist to the same degree with tubes of English manufacture.

When hard tubes are end-annealed for rolling into the tube sheet, care must certainly be exercised to restrict the annealing operation to that portion of the tube which is to be cold-worked in the rolling-in process. Heavily annealed ends or zones extending several inches along the tube length are to be avoided as possibility of electrolytic corrosion between the hard and the soft metal certainly exists.

From Mr. Curley's statement that he was using tubes manufactured by an English company, I would suspect that the tubes were probably of aluminum brass, which mixture carries a high degree of resistance to impingement attack.

It would be interesting for Mr. Curley to examine the annealed ends of his tubes to determine whether the failure had been due primarily to impingement or to electrolytic action incidental to the over-annealing of the tube ends.

R. A. WILKINS.[16]

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[13] Chief Engineer, Tantalum, Fansteel Metallurgical Corporation, North Chicago, Ill.

[14] "Copper and Copper-Base Alloys," by R. A. Wilkins, MECHANICAL ENGINEERING, December, 1936, vol. 58, pp. 809–822.

[15] Assistant electric operating manager, Suffolk division, Long Island Lighting Co., Bay Shore, N. Y. Mem. A.S.M.E.

[16] Vice-president in charge of research and development, Revere Copper and Brass, Inc., Rome, N. Y.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and published in Mechanical Engineering.

Following is a record of the interpretation of this Committee formulated at the meeting of December 18, 1936, and approved by the Council.

Case No. 838

(*Interpretation of Par. P-17*)

Inquiry: Is it the intent of the requirement in Par. P-17 which states that the minimum thickness of plates in stayed surface construction shall be $^{5}/_{16}$ in., that the outside shell of a vertical fire-tube boiler shall be $^{5}/_{16}$ in.?

Reply: It is the opinion of the Committee that it is the intent of Par. P-17 that only the sheets which require support by staying shall be subject to the minimum thickness limitation of $^{5}/_{16}$ in.

Revisions and Addenda to Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place in the Code.

The following proposed revisions have been approved for publication as proposed addenda to the Code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticism and approval from anyone interested therein. It is to be noted that a proposed revision of the Code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

Revise italic note preceding Par. P-1 to read:

These rules apply to the boiler proper and pipe connections up to and including the valve or valves as required by the code. SUPERHEATERS, REHEATERS, ECONOMIZERS, AND OTHER PRESSURE PARTS CONNECTED DIRECTLY TO THE BOILER WITHOUT INTERVENING VALVES SHALL BE CONSIDERED AS PARTS OF THE BOILER AND THEIR CONSTRUCTION SHALL CONFORM TO THE CODE RULES.

Par. P-23. Add following sentence.

The allowable working pressure of a corrugated pipe shall be computed as for the original pipe from which the corrugated pipe is made based on the dimensions of the straight noncorrugated sections. If the corrugations are thinned down in the process of manufacture, the thickness of such corrugations shall be used as the thickness of the pipe.

Pars. P-102*i* and U-68*i*. Insert the following as the second sentence of the sixth sections:

When a grid of the Buckey type is employed to reduce scattered radiation, the above ratio may be reduced to five.

Par. P-190. Revise to read as follows:

P-190. In horizontal-return tubular boilers [with longitudinal lap joints], no course shall be over 12 ft long. [With butt-joint construction any length may be used.]

Par. P-191. Add the following:

When the butt strap of a longitudinal joint does not extend the full length of the shell plates, the abutting edges of the shell plate may be welded provided the distance from the end of the butt strap to the edge of the flange of the head or adjacent shell plate is not greater than $4t$ (t = thickness of shell plate).

Pars. P-195*d*, P-195*b*, U-36*d* AND U-36*b*. Add the following sentence:

In determining the amount of reinforcement required under Par. P-268*g* (Par. U-59*g*), the required thickness of a shell as specified therein shall be used.

Par. P-198. Revise definitions of Figs. P-14*c* and P-14*j* to read:

$C = 0.30$ for flanged plates attached to shells, pipes, or headers as shown in Fig. P-14*c* by means of lap-riveted joints, where the corner radius on the inside is not less than 3 times the thickness of the flange immediately adjacent thereto, and where the riveting meets all the requirements for circumferential joints given in Pars. P-181 to P-185. A FLANGED PLATE MAY BE SCREWED OVER THE END OF A SHELL, PIPE, OR HEADER, IN WHICH CASE FAILURE OF THE THREADED JOINT BY SHEAR, TENSION, OR COMPRESSION RESULTING FROM THE END FORCE DUE TO PRESSURE, SHALL BE RESISTED WITH A FACTOR OF SAFETY OF AT LEAST 5, AND THE THREADED PARTS SHALL BE AT LEAST AS STRONG AS THE THREADS FOR STANDARD PIPING OF THE SAME DIAMETER. SEAL WELDING MAY BE USED, IF DESIRED.

$C = 0.75$ for plates screwed into the end of a shell, pipe, or header having an inside diameter d not exceeding 12 in., as shown in Fig. P-14*j*, OR FOR HEADS HAVING AN INTEGRAL FLANGE SCREWED OVER THE END OF A SHELL, PIPE, OR HEADER HAVING AN INSIDE DIAMETER d NOT EXCEEDING 12 IN., AND WHERE FAILURE OF THE THREADED JOINT BY SHEAR, TENSION, OR COMPRESSION, RESULTING FROM THE END FORCE DUE TO PRESSURE [where the hydrostatic end pressure on the head] is resisted with a factor of safety of AT LEAST 5 AND THE THREADED PARTS ARE AT LEAST AS STRONG AS THE THREADS FOR STANDARD PIPING OF THE SAME DIAMETER [both by the threads engaging the flat head and shell, pipe, or header wall and by the reduced cross section of the threaded portion of the shells, pipes, or headers]. Seal welding may be used, if desired.

Par. P-199*a*. Add the following after $C = 175$:

Washers used must be of wrought or cast steel or wrought iron except that copper washers may be used with $C = 135$.

Par. P-218. Add the following at end of first section:

No such allowance shall be made for manhole in the head above the tubes.

Par. P-230. Add the following as (*c*).

c Cast-iron supporting lugs, legs, or ends shall not be used.

Par. P-250 to be lettered as (*a*) and (*b*). The first section is to include the first sentence of the second section. Add the following to (*b*):

If tubes larger than $1^{1}/_{2}$ in. in diameter are expanded by the prosser method, the work shall be completed as required by (*a*).

Par. P-262. Revise to read:

Manhole plates, cover plates, and HANDHOLE PLATES shall be of rolled, forged or cast steel, EXCEPT THAT FOR PRESSURES NOT EXCEEDING 250 LB PER SQ IN., AND/OR TEMPERATURES NOT EXCEEDING 450 F HANDHOLE PLATES MAY BE OF CAST IRON.

Par. P-266. Revise fourth sentence of first section to read:

Gage connections which are filled with

water at a temperature never greater than that of saturated steam at a pressure of 250 lb per sq in. or 406 F shall be of brass, copper, or bronze, OR OTHER NONCORROSIVE COMPOSITION SUITABLE FOR THE PRESSURE AND TEMPERATURE CONDITIONS.

Par. P-290. Make present paragraph section *a*, and add a section *b* to read:

b If safety valves are attached to a separate steam drum or dome, the opening between the boiler proper and the steam drum or dome shall not be less than required by section *a*.

Present Par. P-290 will become section *a*.

Par. P-299*e*. Revise to read:

e In all cases the scheduled working pressure for steel fittings may be adjusted to the actual [maximum] allowable working pressure according to Table A-10 given in the Appendix, EXCEPT THAT when this table is used to determine the pressure rating of a valve or fitting [for service] as a stop valve or between a stop valve and a boiler, the tabulated rating must be multiplied by 0.80 to determine the maximum allowable working pressure OF THE BOILER WHEN [for] the valve or fitting IS TO BE used [when] for feed or blow-off service, in order to meet the requirements of (*d*) [the fifth section].

Valves and fittings of steel construction, equal to the American Standards given in Table A-6 may be used for FEED AND BLOW-OFF SERVICE FOR maximum allowable boiler pressures which have been adjusted as follows:

Par. P-301. Add the following:

If a shut-off valve is used between the boiler and its superheater, the safety-valve capacity on the boiler proper must comply with the requirements of Pars. P-270 and P-274, no credit being taken for the safety valve on the superheater and the superheater must be equipped with safety-valve capacity as required by Par. P-288.

Par. P-308*f*. Revise to read:

All INTEGRAL ECONOMIZERS, waterwalls, or water screens forming parts of a steam boiler etc.

Par. P-317. Make present paragraph section *a*. Add the following:

b When the supply line to a boiler is divided so as to feed a drum in more than one place or to feed more than one drum, it is recommended that each such branch line be equipped with a stop and/or check valve even though the common source is equipped as required by (*a*).

c If a boiler is equipped with duplicate feed ARRANGEMENTS each such arrangement shall be equipped as required by the rules.

d A combination stop-and-check valve shall be considered only as a stop valve and a check valve shall be installed as otherwise required.

e Where an economizer or other feedwater heating device is connected directly to the boiler without intervening valves, the feed valves and check valves required shall in such an arrangement be placed on the inlet of the economizer or feedwater heating device.

Par. P-331*b*. Insert the following as the first sentence:

An authorized representative of the plate manufacturer may duplicate required stamping on any material received or on any parts of same, wherever located.

Par. P-332*f*. Revise items (4) and (5) to read:

(4) [Water] Heating Surface BOILER, in sq ft.
(5) HEATING SURFACE WATERWALL, IN SQ FT.
(6) [5] Year built.

TABLES A-5 AND A-6.

Revise the columns in these tables headed "150 lb" to read "100 lb."

Fig. P-26. Revise by eliminating designation: "Longitudinal Center Line of Shell."

Par. A-18. Add the following:

These restrictions do not apply to the methods of closing the valves by external methods.

Par. H-44. Revise fourth sentence to read:

The vertical dead-end pipe to which [the] A SAFETY valve is attached shall HAVE A MINIMUM CROSS-SECTIONAL AREA NOT LESS THAN THE NOMINAL AREA OF THE RELIEF VALVE REQUIRED BUT IN NO CASE LESS THAN [be at least] 1-in. STANDARD nominal pipe size. [and the vertical distance from the cold-water supply pipe or from the boiler connection to the water-relief valve shall be at least 6 in.]

Add the following sentence after the second sentence.

Diaphragms, valve seats, or disks of rubber or composition liable to fail due to deterioration or vulcanizing when subjected to hot water or steam shall not be used.

Par. M-20. Revise fifth section to read:

The markings required on a boiler shall be stamped with letters or figures at least $^{3}/_{16}$ in. in height on some conspicuous portion of the boiler proper OR THEY MAY BE STAMPED ON A SEPARATE NAME PLATE LOCATED AS REQUIRED AND IRREMOVABLY ATTACHED TO THE BOILER.

Revise *c* of exemptions to Unfired Pressure Vessel Code to read:

c to vessels for containing only water under pressure for domestic supply INCLUDING THOSE CONTAINING AIR, THE COMPRESSION OF WHICH SERVES ONLY AS A CUSHION OR IN AIR-LIFT PUMPING SYSTEMS.

Par. U-1*a*. Revise to read:

a The rules in this section apply to unfired pressure vessels [constructed of materials] herein specified [which are cylindrical in shape, having a combination of diameter and working pressure such that] IN WHICH BOTH (P — 15) (D — 4) is greater than 60, and [to those vessels having a combination of volume and working pressure such that] (P — 15) (V — 1.5) is greater than 22.5

where P = DESIGN WORKING pressure, lb per sq in.,
D = inside diameter of the vessel, in.,
V = volume, cu ft.

THESE EXEMPTIONS APPLY TO EACH SINGLE VESSEL AND NOT TO AN ASSEMBLY OF VESSELS.

Par. U-13*c*. Add the following:

Except that when steel conforming to Specifications S-26 or S-27 is employed for the construction of vessels under the requirements of Par. U-69, the maximum thickness of the plates at the welded joints shall be 1 in. and the maximum carbon content 0.33 per cent for samples taken from any point in the plate.

Par. U-32. Add the following:

When the butt strap of a longitudinal joint does not extend the full length of the shell plates, the abutting edges of the shell plate may be welded provided the distance from the end of the butt strap to the edge of the flange of the head or adjacent shell plate is not greater than $4t$ (t = thickness of shell plate). When so constructed the vessel need not be stamped with the paragraph number as provided in Par. U-66.

Par. U-39. Revise definitions of Figs. U-2*c* and U-2*j*:

$C = 0.30$ for flanged plates attached to vessels as shown in Fig. U-2*c* by means of circumferential lap joints riveted, fusion welded, or brazed and meeting all the requirements therefor, and where the corner radius on the inside is not less than 3 times the thickness of the flange immediately adjacent thereto. A FLANGED PLATE MAY BE SCREWED OVER THE END OF A VESSEL, IN WHICH CASE FAILURE OF THE THREADED JOINT BY SHEAR, TENSION, OR COMPRESSION RESULTING FROM THE END FORCE DUE TO PRESSURE, SHALL BE RESISTED WITH A FACTOR OF SAFETY OF AT LEAST 5, AND THE THREADED PARTS SHALL BE AT LEAST AS STRONG AS THE THREADS FOR STANDARD PIPING OF THE SAME DIAMETER. SEAL WELDING MAY BE USED, IF DESIRED.

$C = 0.75$ for plates screwed into the end of a vessel having an inside diameter d not exceeding 12 in., as shown in Fig. U-2*j*, OR FOR HEADS HAVING AN INTEGRAL FLANGE SCREWED OVER THE END OF A VESSEL HAVING AN INSIDE DIAMETER d NOT EXCEEDING 12 IN., AND WHERE FAILURE OF THE THREADED JOINT BY SHEAR, TENSION, OR COMPRESSION, RESULTING FROM THE END FORCE DUE TO PRESSURE [where the hydrostatic end pressure on the head] is resisted with a factor of safety of AT LEAST 5, AND THE THREADED PARTS ARE AT LEAST AS STRONG AS THE THREADS FOR STANDARD PIPING OF THE SAME DIAMETER [both by the threads engaging the flat head and vessel wall and by the reduced cross section of the threaded portion of the vessel]. Seal welding may be used, if desired.

Par. U-59*p*. Add the following sentence:

When connections are attached by fusion welding under Par. U-70 to riveted vessels which are to be used under the service classification of U-70, the welded connections need not be stress relieved but the vessel must be stamped U-70 as required by Par. U-66.

Par. U-62*a*. Revise to read:

Vessels over 12 in. in diameter AND/OR THOSE OF ANY FORM IN WHICH THE LARGEST DIMENSION OF ANY CROSS SECTION TAKEN AT RIGHT ANGLES TO THE LONGEST DIMENSION EXCEEDS 12 IN. subject to [interior] corrosion, must be so arranged that the interior and exterior of the vessel may be inspected.

PAR. U-69. Revise first sentence to read:

All vessels covered by this code. . . provided the plate thickness of shells and of heads fabricated of more than one piece does not exceed $1^1/_4$ [$1^1/_2$] in., etc.

PAR. U-73*a*. Revise the fifth sentence of the first section to read:

WHERE A WELDED BUTT JOINT IS MADE THE EQUIVALENT OF A DOUBLE-WELDED BUTT JOINT (SEE NOTE IN PAR. U-67), BY USING A BACKING-UP STRIP AND ADDING FILLER METAL FROM ONE SIDE ONLY, THE REINFORCEMENT SHALL NOT BE LESS THAN $^1/_{16}$ IN. [The reinforcement for single welded butt joint should be not less than $^1/_{16}$ in.]

Add the following to the second section:

THE REINFORCEMENT FOR A SINGLE-WELDED BUTT JOINT SHALL NOT BE LESS THAN $^1/_{16}$ IN. THE REINFORCEMENT MAY BE MACHINED OFF IF SO DESIRED.

PAR. U-76*b*. Revise to read:

b Vessels constructed in accordance with Par. U-69 shall be stress relieved where both the wall thickness is greater than 0.58 in., and the shell diameter less than 20 in., and for other wall thicknesses and shell diameters where the [ratio of the] diameter IS LESS THAN $120t - 50$, WHERE t IS THE THICKNESS IN INCHES [to the cube of the shell thickness is less than 100].

PAR. U-95. Add the following:

When the brazed joint does not extend the full length of the sheet, the unbrazed edges may be welded, provided the length of the weld is not greater than $4t$ (t = thickness of shell plate) from the edge of the flange of the head. When so constructed the vessel need not be stamped with the paragraph number as provided in Par. U-66.

Add note before Par. U-120 to read:

These rules may not be used for determination of thickness of walls of tubes that are to be expanded, rolled, or screwed into tube sheets.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Alloys of Iron and Carbon

Vol. I—Constitution. (Alloys of Iron Research Monograph Series.) By S. Epstein. Published for the Engineering Foundation by the McGraw-Hill Book Co., New York and London, 1936. Cloth, 6 × 9 in., 476 pp., illus., diagrams, charts, tables, $5.

REVIEWED BY N. L. MOCHEL[1]

THIS monograph is the seventh, in order of publication, of the Alloys of Iron Research Monograph Series. The six volumes previously published have dealt with: "The Alloys of Iron and Molybdenum," "The Alloys of Iron and Silicon," "The Alloys of Iron and Tungsten," "The Alloys of Iron and Copper," "Principles of Phase Diagrams," and "The Metal—Iron."

These monographs are a concise but comprehensive critical summary of research on iron and its alloys, as reported in the technical literature of the world. They provide a reliable foundation for further research; and they supply to the practical metallurgist, steel worker, foundryman, and engineer the essential information now scattered through more than two thousand journals and textbooks in many languages. These monographs have been prepared in a most painstaking and intelligent manner.

The writer of such a monograph performs a service for all interested, that cannot be measured. Few of us are so gifted that we can readily read the world's literature. Few indeed have the time to try to read more than a limited number of the many publications that are building up a staggering amount of technical literature. Few have the time to separate successfully the wheat from the chaff. The obvious solution to the suggested problem is the publication of monographs that will search out the fundamentals and the truths, and express them to us in a form that can be readily understood.

The monograph under discussion is the first portion of a correlation and critical summary of what the world knows and apparently thinks in the matter of iron-carbon alloys. It deals with the constitution and heat-treatment of these alloys, leaving to a second volume, now in preparation, the summarizing of the tremendous amount of data on the properties of iron-carbon alloys. Obviously, this volume on constitution contains less factual data and more theoretical discussion, much of it still controversial, than the earlier volumes.

This volume will no doubt appeal to many as being the most important of those so far published. One cannot escape the fact that the plain carbon steels constitute the bulk of metals now in use. They are our most important commercial consideration.

Further, a knowledge of the constitution of iron-carbon alloys is quite essential to an understanding of the behavior of practically all other alloys of iron. The presence, or in some cases the absence, of carbon is an important consideration in alloy steels or irons. In the matter of heat-treatment, the reactions that take place in alloy steels are essentially the same as those established for carbon steels, modified only by the effect of the alloy addition. Thus the volume is of fundamental value in the field of ferrous metallurgy.

The subject is treated under twelve general headings as follows:

I Iron-Carbon Alloys
II General Features of the Iron-Iron-Carbide Diagram
III Correlation of Data for the Selected Iron-Iron-Carbide Diagram
IV The Selected Iron-Iron-Carbide Diagram
V The Iron-Graphite Diagram
VI Arrested Transformations, Principles Underlying Hardening
VII Changes on Tempering Iron-Carbon Alloys
VIII The Structure of Iron and Steel
IX Effect of Mass and Furnace Atmosphere in Heat-Treatment
X Operations of Quenching, Tempering, and Carburizing
XI Inhomogeneities in Commercial Iron-Carbon Alloys
XII Factors Affecting the Quality of Commercial Iron-Carbon Alloys

The author first discusses the presence of other elements in commercial iron-carbon alloys; those normally present such as manganese, phosphorus, sulphur, and silicon, then the presence of other alloying elements due to the scrap situation, and the presence of gases. The effect of structure, the variations in supposedly alike steels, "prenatal influence," nonmetallic inclusions, and the effect of the steel-making processes are some of the features briefly discussed. Some of the limitations in our present knowledge are discussed, again but briefly.

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[1] Metallurgical Engineer, South Philadelphia Works, Westinghouse Electric & Manufacturing Co., Lester, Philadelphia, Pa.

Three chapters are then devoted to the selection of an iron-iron-carbide diagram. No diagram is so widely useful as the iron-carbon diagram. The general features of the diagram are first considered. A great amount of data are then critically reviewed, and little bits of the "jig-saw" puzzle carefully selected from here and there, until a proposed iron-iron-carbide diagram is built up. Many will probably want to follow through the two "selecting" chapters in detail; many more will pass quickly to the proposed diagram and breathe a sigh of relief and of thanks to the author, that he has laboriously and painstakingly considered all the literature, and that he has given us this, the best picture that can be constructed. In the closing part of the chapter, the uncertainty of the selected diagram, and the gaps in the knowledge are frankly reviewed.

An iron-graphite diagram is also proposed, of the double iron-cementite iron-graphite type. There is a discussion of stability and instability, and of the mechanism of graphitization.

Five chapters are then devoted to the matter of heat-treatment. Following directly from the diagrams, the importance of arrested transformations is emphasized. The principles underlying the hardening and tempering of steel and iron are discussed at length. It is very refreshing to find that the very recent theories and experiences are recorded and discussed. Dimensional changes are very important in practice, and this feature has been properly recognized. The so-called macrostructure and microstructure of iron-carbon alloys are discussed. The microstructural constituents are classified and described sufficiently for general purposes. The effect of mass, of furnace atmosphere, and a chapter on the more practical aspects of heat-treatment will be of value to those actually engaged in such work.

The closing sections dealing with inhomogeneities in commercial materials, and of the several factors affecting the quality of such materials, rounds out the discussion in a very excellent manner.

An excellent bibliography listing 675 references between the years 1890 and 1935, a names-index listing the authors of all references, and a carefully perpared subject index have been provided.

The book will prove of value, as a reference book, to all interested in the preparation and use of iron and steel.

Money and Industry

THE BEHAVIOR OF MONEY, by James W. Angell. McGraw-Hill Book Company, Inc., New York, N. Y., 1936. Cloth, 6 × 9 in., 207 pp., $3.

THE GENERAL THEORY OF EMPLOYMENT, INTEREST, AND MONEY, by John Maynard Keynes, Harcourt, Brace and Company, New York, N. Y., 1936. Cloth, 5.5 × 8.5 in., 403 pp., $2.

MANAGING THE PEOPLE'S MONEY, by Joseph Ernest Goodbar. Yale University Press, New Haven, Conn., 1935. Cloth, 6.5 × 9.5 in., 578 pp., $4.50.

MONEY, by Edwin Walter Kemmerer. The Macmillan Company, New York, N. Y., 1935. Cloth, 5.5 × 8.5 in., 406 pp., $2.50.

MONEY AND BANKING, by George William Dowrie. John Wiley and Sons, Inc., New York, N. Y., 1936. Cloth, 6 × 9 in., 512 pp., $3.25.

REVIEWED BY E. DILLON SMITH[2]

THE monetary and banking system is like an automatic machine; it is taken for granted so long as it functions to the satisfaction of the users. But when the monetary system weakens a great many people have as many "cure-alls," none of which seems to be based on any rational scientific analysis. The data presented in the works by Angell, Keynes, and Goodbar are analyzed by the "scientific method;" this analytical approach is most gratifying to the engineer and in this respect these monetary books differ from others.

It is a familiar truism that, except for the usually unimportant phenomenon of hoarding, the possession of money is merely a means to an end, not an end in itself. A corollary of almost equal importance is carried with this truism. If one is placed at the apex of the total flow of economic activity which is occupied by the individual consumer and tries to see the physical movements of specific units of money that is paid for goods and services, whether currency or bank deposits, it is evident that most of these movements are essentially circular in character, as a result of payments for one's services and produced goods. When the industrialist fully understands this behavior of money, together with other phenomena that have been investigated by Angell, he is then equipped to serve the economy with greater efficiency. Angell's most important conclusion on money behavior is as follows: "Both the quantity and the exchange velocity of circulating deposits for the country as a whole move *with or after*—not before—the rough aggregate of the general measures of volume of production and wholesale activity, but not with any one of these measures taken separately, or with commodity prices." This inference indicates, first, that certain recent proposals for monetary action and control which deliberately induced change in the quantity of bank deposits or of currency will not produce, with confidence and with certainty, desirable and resonably prompt effects upon the general volume of economic activity; money outlays and increased prices, or either independently, will not bring prosperity.

Secondly, the industrialist has a rather definite check on the advisability of continuing any managerial policy, because he can determine whether the industrial activity is a concomitant of, or false move toward, true and lasting prosperity of the consumer. It would seem that such an approach to the management of the nation's and entrepreneur's policies would be a step forward in removing the "guess work" entering into decisions. Further facts as revealing as the foregoing are awaiting the reader of Angell's book.

Keynes' book is perhaps one of the most constructively critical books on economics to appear in a decade or so; it demands wholehearted study; it is not "light reading;" it analyzes the existing economic problem and not some hypothetical one. The author assails the adequacy of existing orthodox economic theory as a means of handling the problems of fluctuations in employment, trade cycles, and profits. He shows, for example, that lowering of wages does not increase employment, and then demonstrates that it is in effect the keeping up of effective demand which will increase employment.

Keynes significantly indicates that the rate of new investment is determined by the physical conditions of supply in the capital goods industries, the state of confidence concerning the prospective yield, and the psychological attitude to liquidity and the quantity of money in terms of wage units. A shift in the rate of investment is directly proportional to the rate of consumption, and the ratio of these two factors gives an investment multiplier. But since the investment multiplier equals the employment multiplier, the increment of employment can be directly determined by that ratio. A change in employment, however, is likely to alter the liquidity preference of people, with the result that the dynamic relationship among these factors will influence the position of equilibrium. Hence it is easy to see the extreme complexity of the actual course of economic events.

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[2] Functional adviser on economics to the Management Division, The American Society of Mechanical Engineers.

The next problem that confronts the industrialist, after he himself understands the behavior of money and its relation to the social welfare of his employees and consumers, is to convince the bankers that they should be as concerned over industrial stability as over immediate safety of their deposits; bankers should manage with the producer for progress and stability. Thus, bank managers should know the effect which various types of loans have upon business, and then proceed to grant or to refuse credit on the basis of this relationship rather than upon certainty of repayment and profit.

Among other things this is what Goodbar discusses. He gives a fundamental and understandable exposition of the relation of money to bank credit, of bank credit to business and industry, and discloses the relation between bank credit and dependable consumer purchasing power. It reaches deep into fundamental causes, and proposes practical remedies which Goodbar characterizes as "evolutionary rather than revolutionary."

For example, he believes "it neither desirable nor practically possible to *isolate* the American money and banking system from the outside world. But *insulation* is a different matter." A case at point is how England insulated her own economic structure from monetary disturbances in other countries, with a conspicuous degree of success, since she went off gold in 1931. The discussion of the capital goods industry is of direct importance to every engineer. In essence, the author believes that the intelligent management of the people's money will induce a condition of ordered and reasonably stable prosperity and enable a reasonable progress to be made in promoting the security and the welfare of the individual.

If the engineer has not studied the existing orthodox money and banking theory, the books by Kemmerer and Dowrie are recommended. Kemmerer is one of this country's best known authorities on money; no less than 13 foreign nations have summoned him to minister to their currency ailments, but when the "dollar was sick" he was not called in. Dowrie's treatise not only presents the theory of money but enters into a practical and concise introductory study of banking.

The whole emphasis of these books has been toward a complete, terse, and accurate understanding (by the engineer) of the function and relationship between money and industry.

Books Received in Library

A.S.T.M. STANDARDS ON TEXTILE MATERIALS, prepared by Committee D-13 on Textile Materials. Specifications, Tolerances, Methods of Testing, Definitions and Terms. American Society for Testing Materials, Philadelphia, October, 1936. Paper, 6 × 9 in., 295 pp., illus., diagrams, charts, tables, $2. The standards of the Society for Testing Materials are conveniently collected in this volume, and accompanied by abstracts of seven important papers on textiles presented at the 1935 meetings of the organization.

ACCOUNTING PRINCIPLES FOR ENGINEERS. By C. Reitell and C. Van Sickle. Second edition. New York and London, McGraw-Hill Book Co., 1936. Cloth, 6 × 9 in., 518 pp., charts, tables, $4. The first edition appeared under the title, "Cost Finding for Engineers." The book sets forth the elementary principles of accounting upon which accurate cost findings are based, including accounting technique, basic principles of valuation, factory controls, revenue accounts, and the outline of advanced cost finding. The book is based upon a course given at the University of Pittsburgh.

ATLAS METALLOGRAPHICUS, Bd. 2, Lieferungen 1–4, Tables 1–32, Abbildungen 1–229. Gebrüder Borntraeger, Berlin, 1936. Paper, 8 × 11 in., 32 pp. + ext., diagrams, charts, tables, 30 rm. These four installments of this important atlas of metallography are devoted to gray cast iron. A brief discussion of the constitution and structure of gray castings and methods of polishing and etching is given, accompanied by 229 excellent reproductions of photomicrographs. These illustrations present a great variety of structures and are accompanied by brief descriptions.

DIE BEARBEITUNG DES ALUMINIUMS. By E. Herrmann and E. Zurbrügg. Second edition. Akademische Verlagsgesellschaft, Leipzig, 1936. Paper, 6 × 9 in., 117 pp., diagrams, tables, 4 rm. A brief handbook intended for workmen, foremen, etc., which gives a simple, practical account of the manipulation of aluminum in the shop. Methods of bending, stamping, turning, riveting, and welding are described, as well as methods of finishing and cleaning.

BÉTON ARMÉ (Agenda Dunod), by V. Forestier. Tenth edition, 336 pp.; CONSTRUCTION MÉCANIQUE, (Agenda Dunod), by J. Izart. Fifty-sixth edition, 340 pp.; ÉLECTRICITÉ (Agenda Dunod), by L.-D. Fourcault. Fifty-sixth edition, 392 pp.; MÉTALLURGIE (Agenda Dunod), by R. Cazaud. Fifty-third edition, 328 pp.; MINES (Agenda Dunod), by E. Stalinsky. Fifty-sixth edition, 300 pp.; PHYSIQUE INDUSTRIELLE (Agenda Dunod) by J. Izart. Seventeenth edition, 374 pp. Dunod, Paris, 1937. Cloth, 4 × 6 in., diagrams, charts, tables, 20 fr. each. These pocketbooks contain numerical and other data frequently wanted by engineers engaged in machine construction, reinforced concrete, electrical engineering, mining, metallurgy, and power-plant work. They are small enough for the pocket, are revised annually, and are sold at a very low price.

BOOK OF A.S.T.M. STANDARDS issued triennially. Two volumes. American Society for Testing Materials, Philadelphia, Pa. 1936. Leather, 6 × 9 in., illus., diagrams, charts, tables, part 1, 898 pp., $7.50; part 2, 1477 pp., $7.50 two parts, $14. All the standard specifications, test methods, recommended practices, and definitions which have been formally adopted by the Society are contained in these volumes, one of which covers metallic materials, the other nonmetallic ones. Since the previous edition, many standards have been revised and many new ones adopted, making the new issue indispensable.

CONGRÈS INTERNATIONAL DES APPLICATIONS ÉLECTROCALORIFIQUES ET ÉLECTROCHIMIQUES, Schéveningue, June, 1936. Recueil des Travaux et Compte-Rendu des Séances. Publié sous la direction de l'institution Néerlandaise des Applications Electrocalorifiques et Electrochimiques, Secrétariat: Arnhem, Nachtegaalspad 1, Pays-Bas. Moorman's Periodieke Pers N. V., La Haye, September, 1936. Cloth, 6 × 10 in., 336 pp., illus., diagrams, charts, tables, 6 guilders. The proceedings of this congress on electric furnaces and electrochemistry include papers on industrial electric heating, electric furnaces, and the heat-treatment of metals, together with reports on various related topics. Some papers are in English, the remainder in French or German.

FLUGLEHRE, Vorträge über Theorie und Berechnung der Flugzeuge in elementarer Darstellung. Fifth edition. By R. von Mises and K. Hohenemser. Julius Springer, Berlin, 1936, Cloth and paper, 6 × 8 in., 342 pp., diagrams, charts, tables; paper, 13.50 rm.; cloth, 14.70 rm. This text, which originated in lectures given to the flight officers of the German army in 1913, appears in a new edition prepared by Dr. Kurt Hohenmeiser. It provides an introductory course in the mechanical principles that underlie modern aviation, in which higher mathematics is not used. The present edition has been thoroughly revised and modernized, especially with respect to the design of propellers, Diesel engines, and rotary-wing flight.

FORSCHUNGSHEFT 381. STRÖMUNGSFORM UND DURCHFLUSSZAHL DER MESSDROSSELN. By F. Kretzschmer. V.D.I. Verlag, Berlin, November–December, 1936. Paper, 8 × 12 in., illus., diagrams, charts, tables, 5 rm. This report presents the results of a study of flow through orifices, undertaken to throw light upon the laws that govern it. The basis for the theory of orifice friction and the coefficients of flow and resistance are discussed.

HILFSBUCH FÜR DIE PRAKTISCHE WERKSTOFFABNAHME IN DER METALLINDUSTRIE. By E. Damerow and A. Herr. Julius Springer, Berlin, 1936. Paper, 6 × 10 in., 80 pp., illus., diagrams, charts, tables, 9.60 rm. This small book is intended as a reference work for the mechanical testing laboratory. It contains brief outlines of the usual methods for acceptance tests of materials, together with a collection of tables used in determining the strength, elongation, contraction, and hardness of materials, also a selection of conversion tables. The book will simplify the calculating of test results.

INDUSTRIEGASBRENNER UND ZUGEHÖRIGE EINRICHTUNGEN. Kohle, Koks, Teer, Bd. 35. By E. Sachs. Wilhelm Knapp, Halle (Saale), 1937. Cloth and paper, 7 × 9 in., 132 pp., illus., diagrams, charts, tables; paper, 6.30 rm.; bound, 7.35 rm. in U.S.A. This monograph provides an extensive survey of modern industrial gas burners and their accessories, intended to guide the engineer and factory owner in the selection of equipment. The characteristics of the different burners are explained.

Kalender für Gesundheits- und Wärme-Technik (Hermann Recknagels). Edited by Otto Ginsberg. 39 Jg. R. Oldenbourg, Munich and Berlin, 1937. Cloth, 4 × 7 in., 294 pp., diagrams, tables, 4.50 rm. This calendar provides, in convenient pocket size, practical information on heating, ventilation and air conditioning.

Principles of Electrical Engineering, Theory and Practice. By G. C. Blalock Second edition, McGraw-Hill Book Co., New York and London, 1936. Cloth, 6 × 9 in., 584 pp., illus., diagrams, charts, tables, $4. The special purpose of this book is to provide a course in electrical theory and practice adapted to the needs of students who are preparing for work as civil, mechanical, or chemical engineers, but it may also be used by students of electrical engineering as an introduction. Fundamental principles are presented concisely, with frequent references to practical applications. The new edition has been revised and rearranged, and some new material added.

Punches and Dies, Layout, Construction, and Use. By F. A. Stanley. Second edition. McGraw-Hill Book Co., New York and London, 1936. Cloth, 6 × 9 in., 476 pp., illus., diagrams, charts, tables, $4. A practical guide for diemakers, toolmakers, and draftsmen, in the design, construction, and use of tools for pressworking metal. This edition has been thoroughly revised in the light of recent developments and new material added.

Robert Hallowell Richards, His Mark, an Autobiography. Little Brown & Co., Boston, 1936. Cloth, 6 × 9 in., 329 pp., maps, tables, $3. Professor Richard's life automatically becomes a history of the early days of the Massachusetts Institute of Technology, for he entered its first class as a student in 1865, became an instructor upon graduation and remained with it until his retirement in 1914. His autobiography is the record of a happy, busy life as a teacher and engineer, full of pleasant anecdote and reminiscence of men and experiences.

Story of the Gems. By H. P. Whitlock. Lee Furman, New York, 1936. Cloth, 6 × 9 in., 206 pp., illus., diagrams, $3.50. The Curator of Gems at the American Museum of Natural History has written a popular, authoritative handbook, illustrated by admirable photographs and a large color plate of specimens in the Morgan collection. He tells where the various precious, semiprecious and ornamental stones are found, how they are identified and the methods used in cutting them. Much interesting and curious information is provided.

Das Technische Eisen, Konstitution und Eigenschaften. By P. Oberhoffer, W. Eilneder and H. Esser. Third edition. Julius Springer, Berlin, 1936. Cloth, 7 × 10 in., 642 pp., illus., diagrams, charts, tables, 57 rm. This new edition of Oberhoffer's work is, as stated on the title page, "verbesserte und vermehrte." Literature references extend to the close of 1935, but are hardly complete. This is perhaps ascribable to the tremendous territory covered: Binary and ternary diagrams, influence of temperature on the properties of steels, influence of working on the structure and properties of steels, malleable iron and cast iron. Although hardly suitable as an undergraduate text, this should be a valuable reference book.

THIS MONTH'S AUTHORS

J. W. Yant, whose paper on "Magnaflux Inspection of Pressure-Vessel Welds" appears in this issue, is in the engineering department of the Standard Oil Company of Indiana, Whiting, Ind. Mr. Yant was graduated from Purdue University in 1928 in the school of mechanical engineering. For the past three years he has been engaged in refinery-inspection work, largely in the inspection of pressure vessels.

T. C. Rathbone, author of the article in this issue on "Detection of Fatigue Cracks by the Magnaflux Method," and chief engineer in charge of research and inspection, turbine department, Fidelity & Casualty Co., New York, N. Y., is a graduate of the University of Michigan with the degree of B.C.E. During the War he served with the 318th Engineers (Sappers) in the sixth division of the A.E.F. After the War he entered the employ of the Morse Drydock & Repair Co., Brooklyn, as assistant engineer, working as a specialist on dynamic balancing. In 1922 he became associated with the Philadelphia Works of the Westinghouse Electric & Manufacturing Co., where he was engaged in the large turbine division as designer and assistant engineer in charge of balancing-machine development and vibration investigation, later becoming experimental engineer in charge of the experimental section. Mr. Rathbone is a member of the A.S.M.E.

R. F. Cavanagh, superintendent of engineering, Fidelity & Casualty Co., New York, N. Y., writes on "Magnaflux Inspection of Boiler Drums and Unfired Pressure Vessels." Mr. Cavanagh was for eight years engineer with the Merritt Chapman Scott Corporation in marine wrecking and salvage work, and for fifteen years has been in charge of insurance inspection work.

At the 1936 Annual Meeting of The American Society of Mechanical Engineers the life and accomplishments of George Westinghouse were reviewed in an appropriate commemoration of his birth, ninety years ago. Paul D. Cravath, lawyer, for many years associated with Mr. Westinghouse as member of his legal counsel, delivered on this occasion the address "Westinghouse the Man," published in this issue. The distinguished president of Yale University, James Rowland Angell, delivered a companion address, also published in this issue, in which he evaluated the achievements of Westinghouse as an inventor, engineer, and industrialist. Mr. Paul D. Cravath spoke from the rich experiences of long personal association. President Angell, who had never met Mr. Westinghouse, applied to his estimate of the inventor's achievements the keen understanding of a man whose professional life has made him a competent judge of social values and human motives.

R. L. Sackett, dean of engineering at the Pennsylvania State College, has long been interested in the activities of A.S.M.E. committees on the education of engineers and the training of apprentices. As chairman of the Committee on Student Guidance of the Engineers' Council for Professional Development Dean Sackett has guided the committee's studies of selective tests for young men who are contemplating engineering as a career. His brief paper on "Selection of Engineering Students" deals with phases of this work.

F. L. Wilkinson, Jr., author of the paper on "Chance for Survival of Small Southern Industry," is professor of mechanical engineering at the University of Tennessee. Professor Wilkinson is a graduate of the U. S. Naval Academy, class of 1918. He attended the postgraduate school of the Academy in 1924, and the following year received the degree of M.S. from Columbia University. He served as a commissioned officer in the Navy until 1927, resigning with the rank of Lieutenant. He has served as chief engineer with the Bureau of Smoke Regulation, Knoxville, Tenn., with the engineering department of the Riley Stoker Corporation, Worcester, Mass., and since 1933 on the faculty of the University of Tennessee. He is a member of the A.S.M.E., the S.P.E.E., and Tau Beta Pi.

R. M. Boarts, whose paper on "The Changing Picture in Southern Process Industries" is included in this issue, is associate professor of chemical engineering at the University of Tennessee. Professor Boarts studied at Lafayette College where he received the degree of B.S. in chemical engineering, supplementing this with postgraduate work at the University of Michigan. His experience includes three years on the design and construction of the Springwells Filtration Plant for the Detroit Water Board and two years as chief draftsman and chemical engineer with Comstock & Westcott, Inc., industrial engineers, Niagara Falls, N. Y. For the last two years he has taught chemical engineering at the University of Tennessee and in addition has acted as associate chemical engineer on phosphate research for the Tennessee Valley Authority.

F. L. LaQue, author of "Working of Nickel-Base Alloys," which is the "working" part of his paper on "Nickel and Nickel Base Alloys" published in our December issue, is associated with the development and research division of the International Nickel Co., Inc., New York, N. Y., specializing in corrosion problems. He is the author of many papers related to the field in which he is engaged. He holds the degree of bachelor of science in chemical and metallurgical engineering from Queens University in Kingston, Ont.

W. Rupert Maclaurin, author of this month's economic review, "Massachusetts, a Declining State?" is assistant professor in the department of economics and social science at Massachusetts Institute of Technology. He is a graduate of Harvard University, holding the degrees of A.B., M.B.A., and D.C.S.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

Detroit to Be Host to A.S.M.E. at Semi-Annual Meeting, May 17–21

Plans for Unusually Instructive Meeting Being Perfected

PLANS for the 1937 Semi-Annual Meeting of The American Society of Mechanical Engineers, to be held at Detroit, Mich., May 17 to 21, with headquarters at the Hotel Statler, were advanced to a point where the unusual and regular features of the program began to crystallize when Sabin Crocker, secretary of the Detroit Committee, met with the Committee on Meetings and Program on Friday, February 5, and discussed the general outline and details of specific events.

On Wednesday of the same week at a meeting of the Committee on Professional Divisions the technical program, which is to include at least 15 simultaneous sessions at which papers contributed by the divisions will be presented, was reviewed. At both of these meetings a wealth of technical material was found to be available and the distinctive character of the general plan being worked out by the Detroit Committee was accorded hearty endorsement.

Modern Techniques in Mass Production

Mr. Crocker reported that the Detroit Papers Committee, which is headed by Harry T. Woolson, executive engineer of the Chrysler Corporation, has set up a series of six general sessions which will be held on the mornings and evenings of three days, Tuesday, Wednesday, and Thursday, of the meeting and culminate in the dinner scheduled for Thursday evening. On the afternoons of these same days the simultaneous sessions and tours of the professional divisions are to be held. Thus there will be no conflict between the general sessions, at which eminent authorities from the engineering and industrial fields of the Detroit area will develop a broad survey of the modern techniques employed by the mass-production industries typified by the automobile builders, and the special technological problems in which lie the varied interests of the professional divisions.

Monday is to be given over to a meeting of the A.S.M.E. Council and major inspection tours of the Detroit area. A business meeting of the Society, at which the principal business will be the announcement of the results of the members' ballot on proposed changes to the Constitution of the Society, will be held on Monday evening.

As plans are developed to date, all day Friday will be available for additional inspection tours. All persons attending the meeting will be able to participate in these tours without the conflicting interests of technical sessions that might otherwise interfere with full enjoyment and profit insured by this unusual opportunity to see what industrial Detroit has to offer.

General Sessions to Have Wide Scope and Universal Appeal

The six general sessions have been planned so that they will commence with an introductory address on the first day on the scope and purpose of the planned program. They will conclude with the dinner talk at Thursday's dinner meeting at which the speaker will summarize the week's papers and discussions and the implications arising out of them. As the concluding address is scheduled for the evening a large attendance is assured and engineers who may find themselves compelled to stay at their work during the day may have the benefit of this broader perspective as well as the enjoyment of the social features of the dinner.

HOTEL STATLER, HEADQUARTERS

Acting as sponsor for the first general session is the Railroad Division. The topic for this session will be "Contribution of Automotive Engineering to Other Fields." C. F. Hirshfeld, chief of research of the Detroit Edison Company, who has for several years been acting as consulting engineer on a project to redesign street railways and street-railway cars, will deliver the opening address. Dr. Hirshfeld, in addition to introducing the general topic of the week's sessions and describing the planned program, will provide a historical sketch contrasting the practice in automotive design and production with methods in older engineering fields. Dr. Hirshfeld's well-known ability as an engineer with a particularly comprehensive grasp of trends in engineering practice guarantees a thought-provoking address that should awaken engineers to the possibility of adapting in their own work the successful features of the automotive industry's techniques that have made it a world leader in our industrial society.

Specific emphasis on what is being developed in railroad fields will be placed by Messrs. Tracy V. Buckwalter and O. J. Horger, of the Timken Roller Bearing Co., their paper on "Modern Locomotives and Railroad Equipment," will follow Dr. Hirshfeld's address.

The keynote for Tuesday evening's session will be "Improved Methods of Fabrication."

William S. Knudson, vice-president in charge of operation of the General Motors Corporation, has promised to address the meeting on recent developments in the basic processes of fabrication, such as casting, forging, welding, machining, pressing, and rolling, and to discuss their social and economic implications. This session is being sponsored by the Machine Shop Practice Division. Following Mr. Knudsen's address, Fred W. Cederleaf, of the Excello Aircraft and Tool Company, will present a paper on contribution of machine-tool builders to mass production in the automotive industry.

Lightweight high-speed trains will be the topic of the third general session, scheduled for Wednesday morning, and sponsored by the Railroad Division. Edward G. Budd, president, Edward G. Budd Manufacturing Co., Philadelphia, Pa., builders of the famous lightweight *Zephyr* trains, will speak on the aspects of automotive engineering that have been applicable to railroading. A companion paper on the economics of power for lightweight trains will be presented by Rupen Eksergian, whose authority to deal with this subject is attested by the part he played in the engineering problems of the design of the original *Zephyr*.

The fourth general session, sponsored jointly by the A.S.M.E. Management Division and the Society of Automotive Engineers, is

THE DETROIT SKYLINE

scheduled for Wednesday evening and will be devoted to the subject, "Management and Mass-Production Methods." K. T. Keller, president, Chrysler Corporation, will read a paper on mass-production methods, including the timing of assembly lines, scheduling material deliveries, controlling production to suit dealer demand, advance manufacturing of parts during slack periods, and kindred topics.

W. J. Cameron a Speaker

Also on Wednesday evening W. J. Cameron, of the Ford Motor Company, nationally known for his brief stimulating talks that have become such an important radio feature in the "Ford Sunday-Evening Hour," has consented to speak. It is thought that Mr. Cameron may choose for his topic the decentralization of industry, but as the timeliness of the subject matter is an important aspect of Mr. Cameron's talks, another may be substituted when the program is in more completely crystallized form.

The A.S.M.E. Iron and Steel Division will sponsor the fifth general session at which the keynote is to be "Steel and Its Application." Particularly appropriate for a meeting in Detroit will be the paper by T. F. Olt, supervising metallurgical engineer of the American Rolling Mills Co. on special-purpose steel and development of wide-strip mills to supply the needs of the automotive industry. A companion paper on proper grain structure for deep drawing, and a discussion of other problems involved in the use of wide sheets are being arranged.

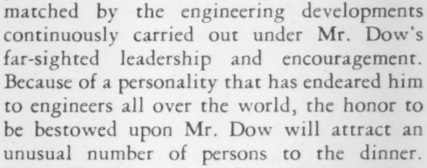
The dinner speaker who will deliver the concluding summary of the implications of the week's program will be Williard T. Chevalier, of the McGraw-Hill Publishing Company. With the address in such competent hands, it is certain that the general and technical sessions will end with a note of high intensity, and that a well-balanced view will be presented of what mass-production methods, as exemplified by Detroit industry, mean in life in America today.

Alex Dow to Receive Honorary Membership

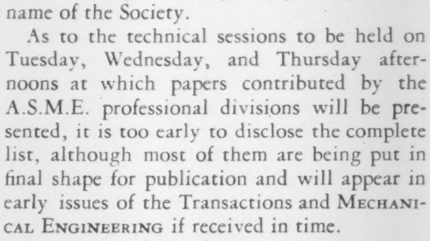
Particularly felicitous because of its setting in Detroit will be the presentation to Alex Dow of honorary membership in The American Society of Mechanical Engineers. Mr. Dow, a past-president of the Society, is nationally and internationally known as the progressive head of The Detroit Edison Company, whose enlightened public policy is matched by the engineering developments continuously carried out under Mr. Dow's far-sighted leadership and encouragement. Because of a personality that has endeared him to engineers all over the world, the honor to be bestowed upon Mr. Dow will attract an unusual number of persons to the dinner. James H. Herron, president, The American Society of Mechanical Engineers, will confer the honorary membership and is expected also to bring a message of greeting in the name of the Society.

As to the technical sessions to be held on Tuesday, Wednesday, and Thursday afternoons at which papers contributed by the A.S.M.E. professional divisions will be presented, it is too early to disclose the complete list, although most of them are being put in final shape for publication and will appear in early issues of the Transactions and Mechanical Engineering if received in time.

At present, fifteen of these sessions are being planned so that five will be held simultaneously every afternoon. An attempt will be made to restrict the number of papers at a given session to two, and in conformity with practice followed in the past, it is hoped that a minimum of conflict in subject matter will result when the final program is whipped into shape so that the engineer interested in a general type of subject matter will not have to try to be in two places at the same time.



CHEVROLET FORGE PLANT



AERIAL VIEW, GREAT LAKES STEEL PLANT

The Committee on Education and Training for the Industries will sponsor two sessions, one jointly with the Management Division, at which apprentice training will be discussed, and the other jointly with the Committee on Relations With Colleges where recruitment problems in obtaining engineering graduates suitably trained for the automotive industry will be discussed.

The Fuels Division joins with the Process Industries Division for one of its two sessions. In cooperation with the Hydraulic Division the Power Division will devote one of its three sessions to the Springwells pumping station, in connection with which an inspection tour is being arranged. At its other sessions the Power Division will present papers on the pooling of power resources in a large industrial center and on matters relating to steam condensers.

In addition to the general session already mentioned the Iron and Steel Division is planning another on the properties of steel when subjected to high-velocity loading.

Metal cutting in drilling, milling, and broaching will be discussed at two sessions that are being planned by the Machine Shop Practice Division.

Under the sponsorship of the Management Division a discussion of the economic characteristics of typical business enterprises will be conducted. Lectures, followed by inspection tours to automobile plants, will be the feature of the Materials Handling Division's contribution to the program, and Detroit is certainly the place to see conveyer assembly lines.

It is probable that the subcommittee on lubrication of the Machine Shop Practice Division will arrange for a session on lubrication. The Process Industries Division is planning a session at which papers on developments in safety glass and the use of rubber in automotive and railway construction will be presented. Also appropriate for the Detroit area will be a session for the discussion of the welding of frames.

FORD RIVER ROUGE PLANT

(Rotunda Building from Chicago's Century of Progress Exposition in foreground with Administration Building just back of it.)

Excursion Trips

There is an abundance of points of interest in and about Detroit for engineers to enjoy, and the Detroit Committee is making the most of its opportunities. The plants of the Detroit Edison Company and the Springwells pumping station will afford much interest to power engineers. Such automobile plants as that of the Ford Motor Company, the Plymouth plant of the Chrysler Corporation, and the Cadillac and Chevrolet gear and axle plants of the General Motors will provide an opportunity to see a variety of mass-production work and motor-assembly lines. Those interested in steel manufacture will have a chance to visit the Great Lakes Steel Plant at Ecorse, Detroit. Other plants and typical Detroit industries and engineering enterprises will be on display, and the schedule of sessions, as already made clear, is being set up so that ample opportunity for these visits will be provided.

Plans are also under way for meetings of numerous A.S.M.E. technical committees, and chairmen are now engaged in communicating with their committee members on the details for them.

Calvin W. Rice Lecture

In conformity with the custom established at Cincinnati two years ago, the Calvin W. Rice Memorial Lecture will be a feature of the Semi-Annual Meeting at Detroit. The name of the lecturer has not been announced. This lectureship, established to perpetuate the spirit of international friendliness between engineers in this country and overseas, brings to the A.S.M.E. meeting every year a distinguished lecturer from some other country, and the subject, which is of a technical nature, is usually treated in a general manner in order to appeal to all engineers. A second lecture, on the oil industry in Michigan, is also being planned. These lectures will be delivered at general afternoon sessions.

Social Events and Sight-Seeing Tours

Mr. Crocker also brought to headquarters assurance that a program of interesting social events and sight-seeing tours was being arranged for the women who may come to Detroit. The city offers many attractions to the sight-seer. The fabrication of an automobile is a fascinating spectacle for old and young of both sexes. Mr. Ford's museum is world famous, and Greenwood Village an interesting excursion at any time. No member need feel that his wife will have a dull time if he finds himself compelled to attend technical sessions in which she would find no interest.

A.S.M.E. Semi-Annual Meetings are conducted by the Society's Committee on Meetings and Program, of which Harvey N. Davis is chairman for the present year. The technical program at these meetings is under the general supervision of the Committee on Professional Divisions, Crosby Field, chairman, which coordinates the contributions of the individual divisions taking part in the program to the extent of sponsoring sessions. Local arrangements are made by a local committee. The Detroit committee appointed so far consists of James W. Parker, general chairman, H. T. Woolson, chairman of Papers Committee, Sabin Crocker, secretary of both General Committee and Papers Committee, W. A. Carter, C. J. Freund, A. N. Goddard, L. T. Knocke, Jervis B. Webb, B. W. Beyer, Jr., chairman, Hotel Committee and L. J. Schrenk, chairman, Publicity Committee.

A.S.M.E. Aeronautic Division to Cooperate With S.A.E. in Washington Meeting

Seven Sessions on Technical Problems Facing the Aircraft Industry Planned for March 11 and 12

AIRCRAFT men are scheduling their work so that they will be able to attend the S.A.E. Aeronautic Meeting in Washington, D. C., March 11 and 12, at the Mayflower Hotel. Sponsored by the Society of Automotive Engineers and its Washington Section, this two-day meeting has the cooperation of The American Society of Mechanical Engineers, the Aeronautical Chamber of Commerce of America, the Air Transport Association of America, and the Institute of the Aeronautical Sciences.

Each of the seven sessions has been designed so that some technical problem facing the aircraft industry will be discussed by an authority on that subject. Oil stability, for instance, will be treated by O. C. Bridgeman, chief of the lubrication and liquid-fuels section, National Bureau of Standards. Under the sponsorship of the Aeronautical Division of The American Society of Mechanical Engineers, L. L. Odell, chief airport engineer, Pan American Airways, will take the important subject of design trends as affecting ground facilities. H. Oliver West, chief engineer, United Airlines, will tell about developments of interior finish of transport airplanes. Two Army Air Corps men, Weldon Worth and Ford L. Prescott, will discuss lubrication and cooling systems, and aircraft-engine reduction gears, respectively.

Among the other authorities reading papers are Eastman Jacobs, National Advisory Committee for Aeronautics; D. P. Barnard, Standard Oil Co. of Indiana; Harlan D. Fowler, Glenn L. Martin Co.; S. D. Heron, Ethyl Gasoline Corp.; R. F. Gagg, Wright Aeronautical Corp.; W. L. Losson, also of Wright; Arnold E. Biermann, National Advisory Committee for Aeronautics; and F. W. Caldwell, Hamilton Standard Propeller Co.

Culminating the two-day get-together of aircraft men will be the banquet. Arthur Nutt, in charge of engineering, Wright Aeronautical Corporation, recently returned from abroad, will discuss European aviation engines.

FINAL PASS, PLYMOUTH ASSEMBLY LINE

Sir John Aspinall, Honorary Member A.S.M.E., Dies

WORD has come of the death on January 19 of Sir John Aspinall whom we mentioned in these columns just last month as having been the first to receive the James Watt International Medal. Sir John, who was eighty-five years old at the time of his death, was knighted in 1917. He was one of the foremost British railway engineers, serving from 1886 to 1899 as chief mechanical engineer of the Lancashire & Yorkshire Railway and then appointed its general manager. He was associate professor of railway engineering at Liverpool University and was a former president of the Institution of Mechanical Engineers. In 1911 he was made an honorary member of the A.S.M.E. A memorial notice will appear later in the Transactions.

The A.S.M.E. Nominating Committee Solicits Suggestions

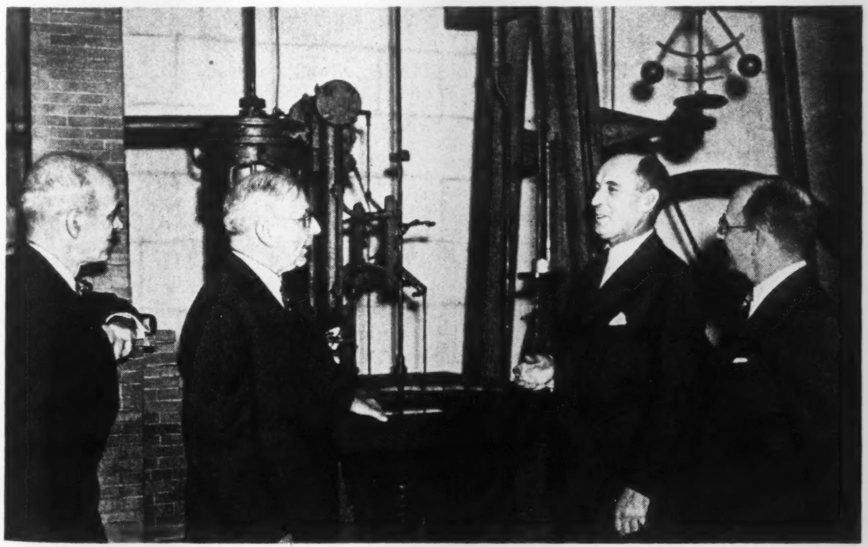
THE 1937 Nominating Committee of The American Society of Mechanical Engineers, Prof. C. M. Allen, chairman, asks for suggestions of names of men qualified to fill the offices of President, Vice-President, and Manager of the Society. These names should be sent by April 1, 1937, to the chairman and secretary of the A.S.M.E. Nominating Committee so that they may be given thorough consideration prior to the national meeting of the Nominating Committee to be held in Detroit, Mich., during the week of May 17.

The selection of Society officers is an important task, and the Nominating Committee asks the cooperation of the individual members of the Society in guiding its important deliberations.

Officers should be men of prominence and leadership, with time to devote to Society affairs. Previous service on committees and knowledge of Society affairs is a factor of importance. The president and vice-president must be of the member grade; managers may be of any grade of membership. Suggestions may be sent to the chairman of the Committee, Prof. C. M. Allen, Worcester Polytechnic Institute, Worcester, Mass., or to the Secretary, F. M. Gibson, American Sugar Refining Co., 49 S. 2nd St., Brooklyn, N. Y.

Members to Ballot on Proposed Amendments to Constitution

WITHIN the coming weeks members of The American Society of Mechanical Engineers will receive by mail copies of proposed amendments to the Constitution of the Society. A letter ballot will accompany each copy of the proposed amendment and every member is requested to execute this ballot and return it within the time specified to the Society headquarters. At the Semi-Annual meeting of the Society, to be held in Detroit, Mich., May 17 to 21, the results of the ballot will be announced at the business meeting of the Society, scheduled for Monday evening, May 17, at the Hotel Statler.

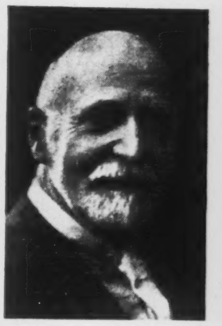


Gladys Muller

A.S.M.E. OFFICIALS VISIT THE FRANKLIN INSTITUTE, PHILADELPHIA

(In addition to modern mechanisms, this half-size-scale model of James Watt's high-pressure, double-acting, Sun and Planet condensing engine attracts wide attention from all engineers who inspect it in the Hall of Prime Movers of The Franklin Institute, Philadelphia. Reading from left to right: Henry S. Harris, former chairman, A.S.M.E. Philadelphia Section; James H. Herron, Cleveland, Ohio, president of the A.S.M.E., Henry Butler Allen, secretary and director of The Franklin Institute, and J. P. Harbeson, Jr., present chairman, A.S.M.E. Philadelphia Section.)

Edison Medal Awarded to Alex Dow



ALEX DOW

THE Edison Medal for 1936 has been awarded by the American Institute of Electrical Engineers to Alex Dow, "for outstanding leadership in the development of the central-station industry and its service to the public."

The Edison Medal was founded by associates and friends of Thomas A. Edison, and is awarded annually for "meritorious achievement in electrical science, electrical engineering, or the electrical arts" by a committee consisting of twenty-four members of the American Institute of Electrical Engineers.

The medal was presented to Dr. Dow during the winter convention of the American Institute of Electrical Engineers held in the Engineering Societies Building, New York, N. Y., January 25–29, 1937.

Dr. Dow, who is president of the Detroit Edison Company, is an honorary member and past-president of The American Society of Mechanical Engineers, a member of the American Society of Civil Engineers, the Institution of Electrical Engineers (Great Britain), and a charter member and past-president of the Detroit Engineering Society. He has recently been elected an honorary member of the A.S.C.E.

Part-Time Courses for Graduate Engineers

A SECOND group of part-time graduate courses in engineering and related subjects for engineers employed in the Chicago area is being offered by Armour Institute of Technology, Lewis Institute, University College of the University of Chicago, and the Division of University Extension of the University of Illinois. These courses were planned by the Education Committee of the Western Society of Engineers in cooperation with these institutions and are the result of the enthusiastic reception given the first group which were offered in September, 1936, and in which approximately 300 students were enrolled.

The courses cover metallography; mechanical, electrical, civil, and chemical engineering; engineering science; and chemistry. They are intended to present an opportunity for engineering graduates to secure additional training in specific fields and, when desired, to work for an advanced degree. Further details regarding these courses can be secured from the Education Committee of the Western Society of Engineers, 205 West Wacker Drive, Chicago, Ill., or from any of the cooperating colleges.

A.S.M.E. Special Research Committee on Lubrication Meets

Three Actions of Particular Interest to Members; Personnel of Committee

THE second meeting of the reorganized A.S.M.E. Special Research Committee on Lubrication was held in New York on Monday, February 1. Twelve of its sixteen members were present and took a lively interest in the discussion of the items on the order of business.

Items of General Interest

Three of these items are of general interest to the readers of MECHANICAL ENGINEERING:

(1) The committee decided to continue the development of its selective bibliography of the literature on lubrication and lubricants together with the abstracts of important articles. W. E. Campbell is in charge of this activity.

(2) It was decided also to prepare each year a report of progress in lubrication research made during that period. It is expected that this report, which will take the form of a technical paper, will be printed in the publications of the Society.

(3) The support of further experimental work on the effect of pressure on the viscosity of lubricants and the mathematical implications of these relations was considered to be essential by the members of the committee.

Personnel of Committee

The personnel of the new committee is as follows: Prof. George B. Karelitz, chairman, department of mechanical engineering, Columbia University, New York, N. Y.; S. J. Needs, secretary, research engineer, Kingsbury Machine Works, Philadelphia, Pa.; Almon L. Beall, research engineer, Wright Aeronautical Corporation, Paterson, N. J.; Dr. Oscar Bridgeman, chief, lubrication and liquid-fuels section, National Bureau of Standards, Washington, D. C.; W. E. Campbell, member of technical staff, Bell Telephone Laboratories, New York, N. Y.; Hans Dahlstrand, engineer in charge of steam-turbine department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.; Prof. H. A. Everett, department of mechanical engineering, School of Engineering, Pennsylvania State College, State College, Pa.; Dr. Alan E. Flowers, engineer in charge of development, the DeLaval Separator Company, Poughkeepsie, N. Y.; R. C. Geniesse, engineer, Atlantic Refining Company, Philadelphia, Pa.; Raymond Haskell, industrial engineer, technical division, The Texas Company, New York, N. Y.; Mayo D. Hersey, Kingsbury Machine Works, Philadelphia, Pa.; G. L. Neely, research and development department, Standard Oil Company of California, Richmond, Calif.; Dr. Burt L. Newkirk, professional engineer, 17 Rosa Road, Schenectady, N. Y.; Prof. Arthur E. Norton, Graduate School of Engineering, Harvard University, Cambridge, Mass.; J. F. Pelly, lubrication engineer, Bethlehem Steel Corporation, Bethlehem, Pa.; E. Wooler, chief engineer, The Timken Roller Bearing Company, Canton, Ohio.

1935 St. Louis Aero Papers at Reduced Price

WE ARE informed that a number of copies of the booklet published by the St. Louis Section of The American Society of Mechanical Engineers containing the papers presented at the 1935 Aeronautic Meeting are available at reduced price. This publication was originally offered at one dollar per copy. The remaining copies may be had at fifty cents each—to A.S.M.E. student members, three copies for a dollar. For details concerning the contents of the publication, address E. H. Sager, Washington University, St. Louis, Mo.

Boiler Code Committee Celebrates Jacobus' 75th Birthday

D. S. JACOBUS

ON FRIDAY evening, January 29, at the Engineers' Club, New York, about forty members of the Boiler Code Committee of The American Society of Mechanical Engineers and their guests celebrated the seventy-fifth birthday of Dr. D. S. Jacobus, who is chairman of the committee, and a past-president and an honorary member of the Society.

The birthday dinner followed one of the regular meetings of the committee and inasmuch as Doctor Jacobus had no suspicion of what had been planned, great adroitness and a certain amount of evasion had to be practiced in order to insure his presence.

Henry B. Oatley acted as master of ceremonies for the informal committee that arranged the dinner, and amid laughter and applause read an account of the Boiler Code "football team" on which each member played some characteristic part. As a sports writer, Mr. Oatley is a keen critic of prowess in team play, and he did not hesitate to comment on the weak as well as the strong points of the individual players. He also read from numerous letters and telegrams of congratulation that had been sent by friends of Doctor Jacobus who could not attend.

Following Mr. Oatley's exposé of the personnel of the Boiler Code Committee, H. H. Vaughan, who had come all the way from Montreal to honor his former associate on the Committee, undertook the task of toastmaster and called upon a dozen or more persons to pay tribute to Doctor Jacobus and recall happy days and historic incidents. Dr. W. H. Durand, past-president and honorary member A.S.M.E., spoke for the Society, and C. B. LePage, assistant secretary, for Secretary Davies and the headquarters staff.

H. Leroy Whitney, after a witty preamble, presented Doctor Jacobus, as an expression of the esteem of the Committee and on behalf of its members, a gavel handsomely ferruled in silver on which an appropriate inscription had been engraved.

In acknowledging the gavel and the felicitations and congratulations of his colleagues, Doctor Jacobus spoke of his deep emotion at being thus honored and recalled some of the interesting experiences that had enlivened his association with boiler-code work.

H. H. Judson to Represent Safety Committee

AT ITS regular bimonthly luncheon meeting on January 29, the A.S.M.E. Safety Committee nominated its new chairman, H. H. Judson, for appointment as its representative for a two-year term on the A.S.A. Safety Code Correlating Committee. D. L. Royer, also a member of the Safety Committee, was named as alternate.

Considerable attention was devoted to the educational aspect of the Committee's work and it was decided to offer its services to several local engineering colleges in providing two lecturers for the spring term, one to talk on safety elements of machine design and the other on industrial hygiene. If this venture is successful the hope is to extend it.

Present in attendance at this meeting were: H. H. Judson, chairman, J. B. Chalmers, H. L. Miner, D. L. Royer, T. F. Hatch, W. M. Graff.

Progress on Gasoline and Oil Separators

DEFINITE progress in its work on the development of a standard specification for gasoline and oil separators was made at the meeting which Subcommittee No. 9 on Gasoline, Oil and Grease Separators held at A.S.M.E. headquarters on February 9, 1937. This subcommittee, under the chairmanship of J. J. Crotty, is at work on one of eleven projects at present included within the scope of the Sectional Committee on Minimum Requirements for Plumbing and Standardization of Plumbing Equipment (A40). This meeting followed closely upon one which this group held on December 2, 1936, and represented the seventh meeting of the subcommittee since its organization in 1934.

At this time W. G. Doherty and Daniel Lenihan reported the completion of a draft of a proposed specification for gasoline and oil separators which they had drawn up in accordance with the instructions of the subcommittee at the last meeting. Copies of this proposed specification had been distributed to the members of Subcommittee No. 9 a few days in advance, for their study. This proposed specification covers gasoline and oil separators to be used as part of plumbing and drainage systems which are connected to the public or private sewer system, for the purpose of preventing volatile and nonvolatile liquids immiscible with, and lighter than, water from flowing into the sewer.

The report of Messrs. Doherty and Lenihan was accepted by the subcommittee and the proposed specification will now be revised in accordance with the recommendations which were made by those present on February 9.

Committee Discusses Flow Nozzles and Orifices

SEVEN authorities on the measurement of fluid flow by means of flow nozzles and orifices held a two-day meeting at A.S.M.E. headquarters on February 1 and 2. W. A. Carter, chairman, presided and those present were: H. S. Bean, H. E. Bumgardner, S. A. Moss, W. W. Johnson, R. J. S. Pigott, and R. B. Smith, constituting the entire membership of the committee.

The principal purpose of this meeting was to review the final draft of a new A.S.M.E. report on the approved methods and measurement with the long-radius (U.S.) and the short-radius (I.S.A.) form of flow nozzle, and the orifice plate. Good progress was made during the five sessions which were held so that publication of the report will not now be long delayed.

The official status of this committee is that of a special subcommittee of Power Test Codes Committee No. 19 on Instruments and Apparatus, C. F. Hirshfeld, chairman.

A.S.M.E. Calendar
of Coming Meetings

May 14–15, 1937
National Rayon Textile Conference, Washington, D. C.

May 17–21, 1937
Semi-Annual Meeting
Detroit, Mich.

May, 1937
Graphic Arts Meeting,
New York, N. Y.

June 25–26, 1937
Applied Mechanics Meeting
Cornell University

August, 1937
Oil and Gas Power Meeting
Pennsylvania State College

October, 1937
Wood Industries Meeting
Louisville, Ky.

Local Sections Meetings
See pages 214–216

Cutting-Metals Handbook Nearing Completion

ON TUESDAY evening, March 2, R. C. Deale will describe to a meeting of the A.S.M.E. Metropolitan Section the recent activity of the A.S.M.E. special research committee which for four years has been at work on the extension of the pioneer work of Frederick W. Taylor on the cutting of metals.

L. P. Alford is chairman of the committee and Mr. Deale has served it as executive secretary. The other members and advisers are Messrs. J. A. Carlin, F. C. Colvin, K. H. Condit, R. E. Flanders, Lt. J. H. Garvin, King Hathaway, R. T. Kent, C. N. Lauer, N. B. MacLaren, W. W. Nichols, Erik Oberg, Haakon Styri, Sam Tour, and J. R. Weaver.

The data which form the basis of the text of the handbook have been drawn from many sources. The committee first reviewed the experimental data which have been developed during the past thirty years in Europe and the United States. It then arranged for some original measurements on the cutting of cast iron and steel at Stevens Institute of Technology. Other data have been contributed by the managements of many of the largest and most progressive shops situated in various parts of the country. The text of the handbook has been written, revised, and rewritten a number of times with a view to making it a worthy continuation of Mr. Taylor's "Art of Cutting Metals" which was originally published by the Society in 1907.

The special research committee plans to release the final draft soon to the A.S.M.E. Research Committee for acceptance and publication. Advance notice will be given of its publication date.

With the Student Branches

New Officers for Spring Semester

SEVERAL student branches have reported the election of new officers for the Spring semester. Good luck, boys. ... OHIO STATE BRANCH, Messrs. Robbins, Daberko, Darrow and Turner. ... KANSAS STATE BRANCH, William Gough, J. Milton Kliewer, Clarence Nielsen, J. S. Dukelow, and Richard Wherry. ... NORTHEASTERN BRANCH has two divisions with each division having a separate set of officers. Division *A*, H. G. Wilder, A. P. Curcio, and G. Reed; Division *B*, P. D. Johnson, G. C. Leck, A. C. Beck, and W. J. Diamondstone..... OKLAHOMA A. & M. BRANCH has as its chairman, Leon B. Stinson, winner of the 1936 Student Prize, assisted by Ivan Weaver, Max Wise, Mont Johnston, and Wilford Maxey. ... C. C. N. Y. BRANCH, Michael Friedman, Arthur Cluger, Charles Aaron, Frank Macaluso, Bernard Jaffee, and Alfred Dietrich. ... MISSOURI BRANCH, Thomas O. Thompson, Bradley C. Douglas, and James J. Hill.... KANSAS BRANCH, Richard Coleman, George Russel, George Cobb, and Lathel Johnson. ... NEWARK COLLEGE BRANCH, R. D. Weigand, J. W. Haythorn, W. Wackenhuth, E. Nezbeda, and R. H. Frohboese. ... RICE BRANCH elected James L. Henderson, Kenneth H. Baird, and Fred Briggs after a spirited and brisk period of discussion.

Talks by Student Members

J. H. Vollentine of the TEXAS A. & M. BRANCH gave an illustrated slide lecture on Diesel engines that proved both interesting and instructive to those present. ... WORCESTER POLYTECHNIC BRANCH had Stanley N. McCaslin discuss and illustrate with slides a few high spots of loom study.... ARMOUR BRANCH is continuing its successful plan of having members present such papers as "High-Speed Diesels," by L. J. Janas, "Experimental Fan Characteristics," by W. Hoekert and "Experiments in Shaking Forces," by M. Loftus. ... IOWA STATE UNIVERSITY BRANCH members listened to talks by Jungjohann on "Molding" and by Wehmeyer on "Streamlined Trains." ... H. E. Robbins, secretary of the NORTH CAROLINA UNIVERSITY BRANCH, gave an interesting paper on "Submarines." He illustrated his talk with blackboard sketches. ... TEXAS TECH BRANCH members were told by Al Ray Cooper how an engineer goes about getting a job. He was followed by Martin True who discussed the outstanding features of the new Burlington *Zephyr* train. ... BUCKNELL BRANCH members learned all about ropes from Lester McDowell who illustrated his talk with actual samples. ... Charles Scott, a member of COLORADO STATE BRANCH described the construction of a power-plant furnace boiler which he helped to build. ... CLEMSON COLLEGE BRANCH members had explained to them the methods of wire drawing by C. R. Vaughan. He was followed by M. R. Dewitt who pointed out the difficulties of producing good-quality cast iron from scrap metals due to the growing use of alloys. ... IOWA STATE UNIVERSITY BRANCH at another meeting had talks on "Airplane Engines," by Hudson, "Steam Traps," by Hale, and "Razor Blades," by Mahan. ... LOUISVILLE BRANCH had papers presented by William Klemt on recent developments in steam turbines based on an article in MECHANICAL ENGINEERING, by Bernard Buckle on abrasives and grinding, and by George E. Wuest on air conditioning based on a group of papers in the *Illinois Bulletin*.

Trips and Inspections

The senior members of VILLANOVA COLLEGE BRANCH conducted a boiler test at the Pilgrim State Hospital in Brentwood, L. I. ... NORTHEASTERN BRANCH visited the Watertown Ar-

A.S.M.E. Student Conferences for 1937

Groups	Places	Dates	Hosts
I New England	Providence, R. I.	April 23–24	Brown University
II Eastern	New Brunswick, N. J.	April 19–20	Rutgers University
III Alleghanies	Columbus, Ohio	April 26–27	Ohio State University
IV Southern	Chattanooga, Tenn.	April 19–20	Chattanooga Local Section
V Mid West	Chicago, Ill.	April 19–20	Northwestern University
VI Northern Unit	Kansas City, Mo.	April 9–10	Kansas State College
VI Southern Unit	Stillwater, Okla.	Not decided	Oklahoma A. & M. College
VII Northwest Unit[1]	Pullman, Wash. Moscow, Idaho	Dates not decided	State College of Washington Univeristy of Idaho
VII Central Unit	Laramie, Wyoming	April 23–24	University of Wyoming
VII Southwest Unit	Stanford Univ., Cal.	April 1–3	Stanford University

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[1] This meeting being held under joint auspices at both campuses.

senal. ... Tulane Branch inspected the Johnson Dry Docks, the Johns Manville plant, and the Southern Pacific shops. ... Wisconsin Branch made an inspection trip to the Gisholt Machine Co. where a detailed demonstration of a new static and dynamic balancer was given. ... Stevens Branch visited the offices and pressroom of the *New York Times*. ... Georgia Tech Branch visited the plant of the Tennessee Coal and Iron Railway Co. at Birmingham.

Joint Meetings

On February 11, Duke and North Carolina State Branches were guests of the North Carolina Branch at a joint meeting held at Chapel Hill, N. C. ... Yale Branch and the New Haven Section held a joint meeting on February 10 at Yale University. The speaker was Philip Swain, editor of *Power*, who recently returned from a tour of Europe. He gave a talk illustrated with slides of conditions as they exist in various foreign industrial centers. Besides this, Yale Branch in conjunction with other engineering student branches decided that it would be extremely interesting as well as educational to have certain professors of the university talk on politics and international affairs at joint meetings. So far, the election in this country, fascism, socialism, communism, and the present European situation have been discussed. ... Georgia Tech Branch had a joint dinner and meeting with the Atlanta Section. ... On February 12, Tulane and Louisiana State Branches held a joint meeting at which six papers, three from each branch, were presented. ... Louisville Branch had a joint meeting with the Louisville Section at which motion pictures about electrostatics, acoustics and the manufacture of wire were shown.

Interesting Talks by Outsiders

Pratt Branch members learned about motor-vehicle fleet operation and maintenance from F. K. Glynn, managing engineer of A. T. & T.'s 16,000 motor vehicles. ... Toronto Branch was told of recent developments in aviation in Canada by Don Long. He mentioned that during the past year, a Canadian air-transport company operating out of Sioux Lookout, Ontario, had a higher air-mile tonnage to its credit than all of the American air lines combined. ... The Penn State Branch in cooperation with the Central Pennsylvania Section presented M. M. Frach in an illustrated lecture on the application of photoelasticity in the study of actual stress distributions. ... Tulane Branch welcomed back Waldemar S. Nelson, last year's branch chairman, who talked on the construction of a compressor station on a gas line. ... Maxwell C. Maxwell gave his famous talk on "Loxology" before the Washington University Branch. At another meeting, Prof. A. L. Hughes gave a talk to the members on polarized light and its application. ... Ralph Pruitt, chairman of the Greenville, S. C. Section addressed the Clemson College Branch. ... Dr. Lillian M. Gilbreth spoke to the Newark College Branch on new developments in housing. ... Michigan Branch at a joint meeting with the A.S.C.E. Student Branch had a speaker, George Sandenburgh, City Engineer of Ann Arbor, who illustrated his talk on the new Ann Arbor sewage disposal plant with several reels of motion pictures.

This and That

Texas A.&M. Branch is already preparing plans to act as host to the regional conference to be held there in 1938. A benefit show was staged on February 19, on the campus by the members to raise money for the occasion. ... Northeastern University has a plan whereby half of the students spend ten weeks in industry while the other half attend classes. The two divisions alternate every ten weeks. ... Yale Branch reports that it has 100 per cent enrollment of the juniors and seniors taking mechanical engineering. ... Ohio State and Texas A.&M. Branches are getting ready for the regional conferences by having professors from the English department give them pointers on effective speaking.

Securing Engineering Employment

NEXT June, the engineering colleges will again graduate many embryo engineers who have passed the first milestone on the road to fame and fortune. The next step in their careers is finding a suitable position. Some graduates will be fortunate enough to have been placed even before leaving their college campuses, while others must search diligently for a position. The Engineering Societies Employment Service, which is maintained by the four national engineering societies, is probably one of the best equipped to help recent graduates in finding employment.

This service is available to all student members of the Society for one year after graduation. As the Employment Service is national in its scope, a fairly good knowledge of conditions in all parts of the country is available at the New York, Chicago, and San Francisco offices.

Students desiring to use the Employment Service should request an application for registration from the nearest office or from the headquarters of the A.S.M.E. During March, April, and May, to assist in this connection, the Employment Service will send a copy of its weekly bulletin, listing the positions available, to the honorary chairmen of the Student Branches. This bulletin is especially helpful in connection with positions for which only written applications are received and for those students or recent graduates who cannot make personal application for employment. Those who so desire may subscribe for personal copies of this bulletin.

The subscription rate is $3 for three months or $10 for the entire year. Addresses of the offices to which requests for application blanks or subscriptions to the weekly bulletin should be sent are 29 West 39th Street, New York, N. Y.; 211 West Wacker Drive, Chicago, Ill.; and 57 Post Street, San Francisco, Calif.

Student Conference at Meeting of Louisiana Engineering Society

AT THE student conference held in connection with the second annual meeting of the Louisiana Engineering Society on January 22, 1937, there were present 35 students. The conduct of the meeting was turned over to R. P. Lockett, Jr., president of the engineering student body at Tulane University, by James M. Todd, presiding officer.

H. W. Blakeslee presented a paper on "The Binary Mercury Steam Cycle," revamped from a similar paper for which he received the annual award at the A.S.M.E. Southern Group Conference in 1936 at Birmingham.

After some discussion on the paper, Mr. Lockett called upon R. B. Tucker, chairman of the A.S.M.E. Student Branch at Louisiana State University, who expressed regret that more of his fellow students were not able to be present because of examination schedules. It was later decided that hereafter the conference be held at a more opportune time.

Short talks were given by F. N. Billingsley, chairman of the annual-meeting committee for the Louisiana Engineering Society, Prof. W. B. Gregory of Tulane University, and Prof. B. W. Pegues of Louisiana State University.

The meeting was concluded with a few words from James M. Todd, chairman of the Louisiana Engineering Society Committee on the student conference, and vice-president of the A.S.M.E.

Ohio State Names McQuigg Dean of Engineering

CHARLES E. MCQUIGG

CHARLES E. McQUIGG, director of research for the Union Carbide and Carbon Company in Long Island City, N. Y., will become dean of Ohio State University's college of engineering July 1, President George W. Rightmire has announced.

In its selection, the University has recalled one of its own alumni to the campus since Mr. McQuigg was graduated from Ohio State in 1909 with the degree of engineer of mines.

Although Mr. McQuigg is not a member of The American Society of Mechanical Engineers, he is at present serving on the following committees of the Joint Research Committee on Effect of Temperature on Properties of Metals: Subcommittee No. 2 on Finance; chairman, Subcommittee No. 3 on Projects; chairman, Subgroup "A" on Material Procurement, Treatment, and Distribution; Committee V, Special Committee on Oil Refinery Problems (A.P.I. and A.S.T.M. cooperating); chairman, Special Committee on Proposal of Future Projects; Executive Committee.

Dean Embury A. Hitchcock, member, A.S.M.E., retired as head of the engineering college at Ohio State last summer. Since that time the college has been administered by William D. Turnbull as acting dean. Mr. Turnbull had previously been junior dean of the college.

Rutgers Revises Air-Conditioning Course

RUTGERS University, New Brunswick, N. J., which was a pioneer in giving air-conditioning instruction by correspondence through its Extension Division, has announced the complete revision and enlargement of this course.

The present revision was necessary to familiarize new students with recent applications of the science and changes in typical equipment, apparatus, and control devices. This course now lends itself particularly to group use, covering all phases of air conditioning.

Nevada Has Course Based on the Current Issue of "Mechanical Engineering"

DEAN F. H. SIBLEY of the College of Engineering, University of Nebraska, and honorary chairman of the Branch, passes along an interesting idea in branch work.

He has established a course in mechanical-engineering literature with a half of a college credit allowed for each semester. The course is scheduled as a requirement for the sophomore year and as an elective for those in other years.

The class meets once a week and one or two members give reviews of articles appearing in the current issue of MECHANICAL ENGINEERING. This is followed by general class discussion.

Dean Sibley tells us that there has been an average attendance of about fifteen during the year and he believes it has been a worth-while experiment.

Other Engineering Activities

The Lincoln Arc-Welding Foundation to Award $200,000 in Prizes

E. E. Dreese, Recently Appointed Director, Is Chairman of Jury of Awards

TO STIMULATE intensive study of arc welding, $200,000 will be distributed by The James F. Lincoln Arc-Welding Foundation among winners of 446 separate prizes for papers dealing with this subject as a primary process of manufacture, fabrication, or construction in eleven major divisions of industry.

The principal prize winner will receive not less than $13,700. Other prizes range from $7500 to $100, the latter sum to be awarded each of 178 contestants who receive no other prize, but whose papers are adjudged worthy of honorable mention.

In order to assure equal competitive opportunity, similar prizes are offered in the eleven major divisions of industry covered by the contest. These divisions are: Automotive, aircraft, railroad, watercraft, structural, furniture and fixtures, commercial welding, containers, welderies, functional machinery, and industrial machinery.

Wide diversification of awards is effected by further dividing each major industry into various subclassifications; with entrants required to select in advance the particular subclassification to which their papers will relate.

Contestants, it was announced, must have papers in duplicate on file with the Secretary of the Foundation, at Cleveland, Ohio, not later than June 1, 1938. Prospective entrants should communicate promptly with Foundation Secretary A. F. Davis, P. O. Box 5728, Cleveland, for complete details of the rules and conditions covering awards.

Dr. E. E. Dreese, chairman of the department of electrical engineering at Ohio State University, has accepted the appointment of director of the newly established Foundation. He will act as chairman of the Jury of Awards of the Competition.

In the objects of the Foundation as set forth in the inaugurating resolution it is stated in part that it is desired in the public interest that careful and extensive scientific study, research, and education in respect to development of the arc-welding industry be encouraged, and that through such study and research both the public and modern industry should have the benefit of accurate knowledge and information affecting the application of electric-arc welding to machinery and equipment.

It was established by the Lincoln Electric Company in honor of its president, James F. Lincoln, member A.S.M.E.

Dr. Cottrell to Receive Washington Award

DR. FREDERICK GARDENER COTTRELL, Washington, D. C., who perfected the process by which the cost of helium gas was reduced from $1700 to 10 cents a cubic foot, has been chosen to receive the Washington Award for 1937. This has just been announced in Chicago by Edward J. Mehren, chairman of the Washington Award Commission.

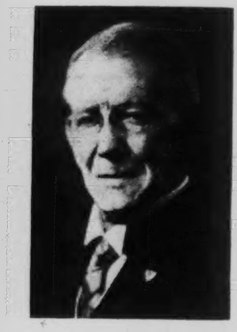
Dr. Cottrell is president of Research Associates, Inc. He is widely known as a chemist and metallurgist, a former director of the U. S. Bureau of Mines and director Fixed Nitrogen Laboratory, U. S. Department of Agriculture. Besides his achievements in the cheap production of helium, Dr. Cottrell is famous for his work in nitrogen fixation, for his processes of cleansing gases of dust and dirt by electrical precipitation, and for research in petroleum technology. The award has been made for his "social vision in dedicating to the perpetuation of research the rewards of his achievements in science and engineering."

In addition to the Washington Award, Dr. Cottrell has received a number of scientific honors. In 1919 he received the Perkin Medal from the Society of Chemical Industry for his notable work in applied chemistry. In 1920 he received the Willard Gibbs Medal from the Chicago section of the American Chemical Society for his work in electrical precipitation.

The Medal of the Mining and Metallurgical Society of America went to him in 1924 for achievements in electrical precipitation and research with gases.

The Washington Award is administered by the Western Society of Engineers in cooperation with the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. Seventeen men compose the Award Commission.

Daniel W. Mead Awarded Norman Medal



DANIEL W. MEAD

AT THE annual meeting of the American Society of Civil Engineers, January 20–22, 1937, Daniel W. Mead, member A.S.M.E., was awarded the Norman Medal for his paper on "Water-Power Development of the St. Lawrence River," a paper which aroused considerable public comment at the time of its publication in the Transactions of the A.S.C.E. This medal was instituted and endowed in 1872 by the late George H. Norman and is awarded annually for a paper which is judged worthy of special commendation for its merit as a contribution to engineering science. Dr. Mead, retiring president and honorary member of the Civil Engineers, is a member of the firm of Mead and Seastone, Madison, Wis., and of Mead and Scheidenhelm, New York.

S.P.E.E. to Meet at M.I.T. in June, 1937

THE forty-fifth annual meeting of the Society for the Promotion of Engineering Education is scheduled for June 28 to July 2, 1937, at the Massachusetts Institute of Technology.

Notice of Hearing

A.S.M.E. Boiler Code Committee

THE A.S.M.E. Boiler Code Committee will hold an open hearing at 10 a.m., March 11, 1937, at the Engineering Societies Building, 29 West Thirty-Ninth Street, New York, N. Y., on the proposed revisions of Table P-2 which covers the maximum allowable pressures in steel tubes for water-tube boilers, as published in the January, 1937, issue of MECHANICAL ENGINEERING, pages 47 to 49.

Fred H. Colvin Thirty Years with "American Machinist"

F. H. COLVIN

FRED H. COLVIN, member of the Society, was tendered a luncheon by his associates of the McGraw-Hill Publishing Co., Inc., and the McGraw-Hill Book Co., Inc., on January 28, which was the thirtieth anniversary of his acceptance of a position on the editorial staff of *American Machinist*. Mr. Colvin was managing editor during the World War, then chief field editor, and since 1921 has been coeditor with Kenneth H. Condit. He is joint author, with Frank A. Stanley, of the American Machinist's Handbook which has had a sale of more than 277,000 copies.

80 Complete Examinations of Civil Engineer Corps

THROUGH the courtesy of G. A. Duncan, assistant to the chief, Bureau of Yards and Docks, Navy Department, we have been provided with a report on the examination of candidates from civil life for the Corps of Civil Engineers, United States Navy, recently held, announcement of which appears in our issue of August, 1936, p. 525. Among other items of interest it is stated that 745 applications were received, reviewed, and graded by the examining board. Of this number of applicants, 236 were selected as having the relative merit to be authorized to take the physical and professional examinations. Of the 140 applicants who reported for the physical examinations 82 passed of whom 80 completed the written professional examination. These 80 represented 43 universities, colleges, and institutions. The examinations are being graded and names of those to be commissioned will be announced shortly. This is the first examination of candidates from civil life to be held since 1925.

Greater N. Y. Safety Council Convention, April 13–15

APPROXIMATELY 40 sessions covering every phase of accident-prevention work are scheduled for the eighth annual convention of the Greater New York Safety Council, which will be held at the Hotel Astor, New York, N. Y., April 13, 14, and 15. Morning and afternoon sessions will be held on all three days. These will be supplemented by dinners of the Institute of Traffic Engineers and the Council on the evenings of April 13 and 14, respectively, a luncheon following the petroleum session on April 14, and one given by the Metropolitan Chapter of the American Society of Safety Engineers on the last day.

Safety Work Good Business

RECENTLY, the National Safety Council requested its members to give their reactions to the fruits of accident-prevention work. Responses received from the more than 5000 companies comprising the membership were culled and published in a booklet entitled "Safety." Contributors include such men as the presidents of Armour & Co., E. I. du Pont de Nemours & Co., General Motors Corporation, Goodyear Tire & Rubber Co., International Harvester Co., Studebaker Corporation, Swift & Co., and Western Electric Co.; vice-presidents of Kimberly-Clark Corporation and Libby, McNeill & Libby; and others of similar importance in American industrial life.

This booklet is being distributed, without charge, to plants throughout the United States to show that safety work is "good business." Copies may be obtained from the National Safety Council, 20 North Wacker Drive, Chicago, Ill.

Engineering Societies Employment Service Has Exceptional Positions Available

WE HAVE been requested by the Engineering Societies Employment Service to publish from time to time a list of such positions as it has been unable to fill from the applications on file.

Many of these positions are of unusual interest and it is our hope that their publication may be of help in finding the right man for the right job.

We shall be glad to hear from the members of the Society as to whether or not they are interested in this service.

* * *

CHIEF SENIOR ENGINEER, mechanical, not over 45. Must be able to supervise entire plant including layout design, production, and research. Must have considerable experience in steel products and be capable executive. Salary, $500–$600 a month. Apply by letter. Location, Middle West. Y-378-C.

RECENT GRADUATE MECHANICAL ENGINEER with one to three years' experience in central-station work. Must be capable of calculating heat balances. Latter experience essential. Apply by letter. Location, New York, N. Y. Y-399.

SALES ENGINEERS, 2, mechanical-engineering graduates with experience in sales and combustion field. In lieu of combustion experience, experience in operation or design of

(*Continued on page 214*)

TWO GREAT PERFORMERS THAT HELP *Cut* Depreciation Costs TO THE CORE

By adding years to the life of your motors and machines, Morse couplings help cut your depreciation costs to the core. Morse builds two types of couplings. *Standard* (all-steel) consists of two facing, hardened-steel sprockets wrapped in a silent chain which is the flexing medium. The entire assembly is enclosed in a grease-packed dust-proof case. *MORFLEX* couplings use rubber as the flexing medium. They are furnished with or without cover, and require no lubrication. Both Standard and Morflex couplings are easy to connect and disconnect. For more information, telephone the Morse Coupling engineer in your territory or write to us here in Ithaca, today.

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Right: MORFLEX rubber-bushing-type coupling without cover. Center: Morse Standard Coupling on the job. Above: MORSE STANDARD chain and sprocket type coupling without case.

MORSE FLEXIBLE COUPLINGS

MORSE CHAIN COMPANY ITHACA N. Y. DIVISION BORG-WARNER CORP.

oil-refinery plants would be acceptable. Salary, $250 a month. Apply by letter. Location, New York, N. Y. Y-431.

Superintendent, 35–45, for large electrical-fittings plant manufacturing wiring devices, sockets, etc. Must have experience in precision work, tool-making problems, and operation punch presses. Engineer who has had charge of large operation with radio parts would qualify. Salary, $5000 a year. Apply by letter. Location, western New York. Y-434.

Manager machinery sales, 30–40. Must have comprehensive sales experience in printing field, and knowledge of methods of printing and presses. Salary, $4000–$5000 a year. Apply by letter. Location, New Jersey. Y-445-C.

Executive Sales Manager capable of laying out and executing complete sales program. Must understand business conditions and relations and be able to train and develop sales force to high efficiency. Apply by letter. Location, Pennsylvania. Y-542.

Associate Editor, graduate mechanical engineer, 30–40, for editorial work. Should have some ability as news writer and some practical experience in industry such as shop work, etc. Salary, $350–$400 a month. Apply by letter. Location, New York, N. Y. Y-666.

Merchandise Sales Manager, mechanical engineer. Must be experienced in modern sales methods. Will take charge of planning, advertising, handling agencies, and salesmen. General knowledge of large industries desirable. Applicant must have qualifications to justify salary of $6000–$12,000 a year. Apply by letter. Location, New York, N. Y. Y-676.

Mechanical Engineer to act as chief engineer, designer, and superintendent. Will supervise design and construction of large power plant. Must be capable of taking full responsibility. Salary, $400–$500 a month. Apply by letter. Location, East. Y-696.

Sales Engineer to build up sales organization for small shovels, cranes, draglines among smaller equipment dealers. Should know equipment, equipment selling, and how to get, train, and help dealers sell. Apply by letter. Location, Middle West. Y-717.

Chief Engineer for company engaged in design and manufacture of hoisting and conveying machinery, to handle force of fifty to seventy-five men. Knowledge of machine design is essential; also experience in handling construction contracts. Must be competent executive. Apply by letter. Location, New York, N. Y. Y-729.

Engineer for editorial work. Duties cover writing of technical, semitechnical, popular, articles for publication technical and trade journals. Articles will concern installations or uses of company's products, new processes, or plant operations. Must be able to consult company's engineers and metallurgists, and magazine editors on requirements. May be called on to help conduct guests through plants at special occasions. Editorial experience on industrial magazine and engineering education equivalent necessary. Apply by letter. Location, East. Y-793.

General Superintendent for complete refinery with daily capacity two thousand barrels. Modern solvent dewaxing and cracking plant under construction. Must have considerable experience in operating refineries, especially with paraffin-base crude. Must also have experience in cracking, contact filtering, and if possible solvent dewaxing, and general administrative work in connection with operations small refinery. Apply by letter. Location, Pennsylvania. Y-828.

Assistant Plantations Manager, 35–45, with experience in rubber plantations. Should understand planting and tapping of rubber trees; also factory operations in smoking rubber. Should be able to handle engineering problems such as road and bridge building, also able to handle men, both white and native labor. Must be executive type with pleasing personality. Salary, $6000–$10,000 a year. Apply by letter. Location, Liberia. Y-877-C.

Plant Superintendent, mechanical engineer, to take charge of small press shop for plastic materials such as bakelite, acetate, or beetleware. Must be thoroughly experienced in design and construction of molds. Will have charge of entire production. Apply by letter. Location, New Jersey. Y-904.

Consulting Engineer, mechanical, mining or metallurgical, with broad experience in heavy industries. Should have thorough knowledge of iron and steel, heavy mining machinery, etc. Salary, $10,000–$30,000 a year. Apply by letter. Location, foreign. Y-950.

Industrial Adviser, mechanical engineer with at least 20 years' broad experience in industrial and manufacturing work. Will act as industrial adviser to foreign government. Salary, $10,000–$30,000 a year. Apply by letter. Y-951.

Assistant Plant Superintendent, 30–40, subject of Sweden, metallurgical or chemical engineer preferred, trained in United States plant. Must be willing to return to Sweden permanently, and must have experience in operation of electric-furnace plant. Salary, $2500–$3000 a year. Apply by letter. Y-954.

Mechanical Engineer to act as general manager. Must have broad experience as chief executive in large manufacturing plant, and be thoroughly conversant with operation and supervision of all departments of factory. Should have held position commanding salary of $15,000–$20,000 a year. Apply by letter. Location, New York, N. Y. Y-961.

Executive, mechanical engineer, to act as vice-president and general manager. Will be in executive charge of manufacturing company, and will be directly responsible for entire operation of company, including sales, engineering, manufacturing. Should have earned at least $15,000 a year. Apply by letter. Location, Pennsylvania. Y-962.

Heating and Ventilating Sales Engineer, 30–40, to solicit sales from the heating trade and industrials. Must have experience in these lines. Apply by letter giving full details of experience and salary expected. Territory, Ohio. Y-1008-C.

Plant Manager, about 40. Should know the pulping business and also have knowledge of resin and resin impregnation. Must have experience in plant management, machinery layouts, etc. Apply by letter. Location, Middle West. Y-1014.

Power Engineer with experience in process steam for industrial plant. Must also have electrical experience. Position with chemical company. Salary, $5000 a year. Apply by letter. Location, South. Y-1015.

National Foreign Trade Week, May 16–22

SUGGESTIONS for the local observance of National Foreign Trade Week, May 16–22, have been prepared by the Foreign Commerce Department of the Chamber of Commerce of the United States. This year marks the third observance of this week, which has a twofold purpose; (*a*) to direct attention to the national importance of the foreign trade of the United States and its relationship to domestic industry and trade and (*b*) to stimulate local surveys and development of foreign-trade possibilities in individual cities and towns and in individual industries and trades. The week containing May 22 has been set aside for the observance of National Foreign Trade Week, to commemorate the sailing of the *S. S. Savannah* on May 22, 1819, from the port of the same name on the first transatlantic round-trip by a steam-propelled vessel. Copies of the bulletin which contains a chart of proposed activities for community groups and sources of material can be secured from the Foreign Commerce Department, Chamber of Commerce of the United States, Washington, D. C.

Local Sections

Coming Meetings

Atlanta: March 1. Georgia School of Technology, Dining Hall, Atlanta, Ga., at 7:00 p.m. Subject: "What the Future Holds for the Young Engineer," by Carl Landgrebe, vice-president, charge of operations, Tennessee Coal, Iron & Railroad Co., Birmingham, Ala.

Cleveland: March 3. Case Club, 10700 Deering Ave., S.E., at 6:00 p.m. Annual dinner meeting with the Case Student Branch. Subject: "Lighter-Than-Air Flight," by Wade T. Van Orman, Goodyear Tire & Rubber Company, Akron, Ohio.

Detroit: March 19. Hotel Statler at 8:00 p.m. This will be a joint meeting with the Engineering Society of Detroit. Subject: "Ordnance Procurement as an Engineering Problem," by Brigadier General H. W. Schull, assistant to Chief of Ordnance, U. S. War Department.

Florida: March 18–20. Meeting to be held

(*Continued on page 216*)

EQUIPMENT ★ ★ FACILITIES ★ ★ PERSONNEL & EXPERIENCE ★

REPUBLIC INSTRUMENTS

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ELECTRICAL FLOW METERS. For metering the flow of steam, water, gas, air, oil, brine, etc. The reading instruments, indicator, recorder and integrator, are remote reading and can be supplied singly or in any combination desired.

MECHANICAL FLOW METERS. A simple mechanical meter, indicating, recording and integrating the flow of fluids.

CO_2 METERS. Provides a continuous record of per cent CO_2 in flue gas measured by the orsat method. Furnished with either mechanical or remote reading indicator and recorder.

DRAFT INSTRUMENTS. Indicating or recording types in single or multiple units. Furnished in all standard ranges of draft and pressure.

THERMOMETERS. A long distance, expansion type thermometer with either single or multiple pen recorder.

LIQUID LEVEL INSTRUMENTS. Remote reading indicators and recorders. Also provided with various types of alarm and control devices.

MULTI-POINT INDICATORS. Will indicate, on separate horizontal scales from two to sixteen units of draft, pressure, flow, temperature, CO_2, etc., in any combination desired.

MULTIPLE RECORDERS. Will record on a wide strip chart, from three to six separate records of flow, temperature, CO_2, pressure, etc., in any combination desired.

PANEL BOARDS. Master instrument and control panels are designed and built for any combination of instruments and controls desired.

BOILER CONTROLS. A centralized, automatic system for controlling steam pressure, combustion, furnace pressure, excess pressure, boiler level, etc. Automatically regulates the fuel and air input to a boiler in measured proportions and in a fixed ratio for the entire load range.

DESUPERHEATERS. A venturi type desuperheater wherein the rate of water flow is controlled by the steam flow in correct proportion to reduce the steam temperature to the degree desired.

REGULATING VALVES. Turbine type valves designed for regulating the pressure and flow of liquids and gases including high pressure superheated steam. Built in accordance with A.S.A. standards for all pressures up to 1,500 lbs. per sq. in.

REGULATORS. For the automatic control of pressure, draft, rate of flow, rate of fuel feed, speed of rotation, liquid level, etc. For proportioning two pressures or flows. Regulators may be either air or oil operated.

STEAM ACCUMULATORS. Designed and built to meet your specific requirements for the storage of high and low pressure steam.

DESCRIPTIVE DATA BOOKS MAILED UPON REQUEST

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REPUBLIC FLOW METERS CO.

2232 DIVERSEY PARKWAY · CHICAGO · ILLINOIS